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TRANSCRIPT OF RECORD.

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1884.

No. ~~545.~~ 255 19

THE CONSOLIDATED SAFETY VALVE COMPANY,
APPELLANT,

vs.

ERASTUS B. KUNKLE.

APPEAL FROM THE CIRCUIT COURT OF THE UNITED STATES FOR THE NORTHERN DISTRICT OF ILLINOIS.

FILED AUGUST 16, 1883.

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1884.

No. 547.

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APPELLANT,

vs.

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1 Pleas in the circuit court of the United States for the northern district of Illinois, held at the United States court rooms in the city of Chicago, in the district aforesaid, before the Hon. Henry W. Blodgett, district judge of the United States for said northern district of Illinois, on Monday, the eighth day of January, in the year of our Lord one thousand eight hundred and eighty-three, in the December term of said court, A. D. 1882, and of our Independence the one hundred and seventh year.

WM. H. BRADLEY, *Clerk.*

NORTHERN DISTRICT OF ILLINOIS, *ss:*

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

Be it remembered that on the sixth day of October, A. D. 1880, came the complainant, by its solicitors, and filed in the office of the clerk of the circuit court of the United States for the northern district of Illinois at Chicago, in said district, its bond for costs and bill of complaint in said entitled cause, which said bond and bill are respectively in the words and figures following, to wit:

2 *Bond for Costs.*

UNITED STATES OF AMERICA,
Northern District of Illinois, } *ss:*

Circuit Court, October Term, A. D. 1880. In Chancery.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE.

I enter myself security for costs in this cause, and promise to pay all costs which may accrue to the opposite party in this action or to any of the officers of this court, and in default of payment by the plaintiff of any costs ordered or adjudged to be paid by it, I hereby agree and stipulate that execution may issue against my property for any costs taxed against it.

Dated this sixth day of October, A. D. 1880.

R. L. TATHAM.

Endorsed: Filed Oct. 6, A. D. 1880.

W. H. BRADLEY, *Clerk.*

3 *Bill.*

UNITED STATES OF AMERICA,
Northern District of Illinois, } *ss:*

In the Circuit Court of the United States for said Northern District of Illinois. Term A. D. 1880.

To the honorable the judges of the circuit court of the United States for the northern district of Illinois, in chancery sitting:

The Consolidated Safety Valve Company, a corporation organized

and doing business under and by virtue of the laws of the State of Connecticut, complainant in this suit, brings this its bill of complaint against Erastus B. Kunkle, a citizen of the State of Indiana, residing in Fort Wayne, in said State of Indiana, herein defendant.

And thereupon your orator complains, and says that heretofore, to wit, on the 25th day of September, A. D. 1866, one George William Richardson, who was and is a citizen of the United States, became and was the true and original inventor of an improvement on steam safety valves, and thereupon, after due proceedings had according to law, letters patent of the United States were duly issued for the said invention by the Commissioner of Patents of the United States to the said George William Richardson, which said letters patent bear date the twenty-fifth day of September, A. D. 1866, and were numbered 58294, as will appear from said original letters patent,
4 which your orator here offers to produce for the inspection of this court upon a hearing of this cause.

Your orator further represents unto your honors that the title to said letters patent became vested in your orator by assignment from said George William Richardson prior to the first day of January, A. D. 1880, and that your orator is now the sole and exclusive owner thereof, and entitled to all rights and privileges under said letters patent; that the invention described in said letters patent is of great value, and has been extensively used and put in practice and operation, and that your orator and its assignor have been exclusively possessed of the same, and that no other person, without their consent or permission, should make, use, or vend articles embodying the said invention as described in said letters patent.

Your orator further shows unto your honors that the said letters patent have been adjudicated and declared valid in a certain suit brought by the said George William Richardson in the first circuit and district of the State of Massachusetts against one Edward H. Ashcroft, in which said cause the said Edward H. Ashcroft, defendant therein, appeared and defended said suit, and set up, as an anticipation of the said invention of the said Richardson, the invention of one William Naylor, which was patented October 16th, A. D. 1866, and described in an English publication
5 called "a provisional specification," dated the 21st day of July, A. D. 1863, and published in the year A. D. 1864, entitled "Specification of William Naylor's Safety Valves," and that in said suit there was introduced in evidence, as showing the state of the art, English letters patent numbered 1038 of April 25th, A. D. 1863, to Charles Beyer; English letters patent of November 9th, A. D. 1859, to Thomas Green; English letters patent No. 1830, dated July 31st, A. D. 1863, to William Naylor; American letters patent, dated November 15th, A. D. 1853, issued to Henry Waterman, and reissue thereof No. 2675 of July 9th, 1867, to said Henry Waterman, together with the American letters patent to the said William Naylor; and after due proceedings and hearing upon the pleadings and proofs and the argument of counsel the said letters patent so issued to said George William Richardson were declared good and valid, and the said Ashcroft was held to infringe, in a decision delivered

by his Honor, Judge Shepley, of said circuit court, on or about the 8th day of January, A. D. 1875, which said decision was affirmed by the Supreme Court of the United States on an appeal, being perfected therein, as by reference to the record of the proceedings in said suit will more fully and at large appear.

Your orator further represents unto your honors that the said defendant, Erastus B. Kunkle, as your orator is informed and
6 believes, at the city of Chicago in said northern district of Illinois, at said city of Fort Wayne, in the State of Indiana, and elsewhere, has, without the consent of your orator, made, used, and sold to others to be used great numbers, but how many your orator cannot tell, of steam safety valves, involving the said invention, so secured to your orator by said letters patent, to the great damage of your orator and in violation of the rights of your orator in the premises.

Your orator is informed and believes that said defendant, Erastus B. Kunkle, pretends to justify the said infringement under certain pretended letters patent for improvement in safety valves, known by the said defendant to be subsequent to the date of your orator's said invention so patented, and a manifest infringement of your orator's letters patent, as aforesaid.

And your orator further represents unto your honors that it has reason to believe, and does believe, that the said defendant will continue to make, use, and sell said article so by him manufactured, in violation of the said rights of your orator unless restrained by injunction of this honorable court, and that the manufacture, use, and sale of said infringement by said defendant has caused great loss to your orator, and will greatly injure and prejudice your orator and cause it great and irreparable loss in the future.

Wherefore, inasmuch as your orator is without remedy in
7 the premises, except in a court of equity, and to the end that the said Erastus B. Kunkle may, if he can, show why your orator should not have relief in the premises, and that he make full, true, direct, and perfect answer to this, your orator's, bill of complaiat, but not under oath, the answer under oath being hereby waived; and that upon a final hearing of this cause the said Erastus B. Kunkle, defendant, be perpetually enjoined from manufacturing, selling, and using the said article so covered by the said letters patent of your orator, and that he be decreed to account with your orator for the profits made by him by reason of such infringement and disregard of the rights of your orator, and to pay over to your orator whatever sum shall be found to be due on such accounting, and such further sum as shall be awarded for damages suffered by your orator in the premises by reason of such infringement by said defendant.

And that your orator shall have such other and further relief as equity may require and to your honors shall seem meet.

And may it please your honors to grant unto your orator the writ of injunction issuing out of and under the seal of this court, perpetually enjoining or restraining the said defendants, his attorneys, agents, servants, and workmen from directly or indirectly manu-

facturing, using, or selling the said safety-valves described
8 and claimed in said letters patent so owned by your orator, and that a temporary injunction be granted in like manner pending a hearing and final decree in this case.

And may it please your honors to grant unto your orator the writ of summons in chancery issuing out of and under the seal of this honorable court, directed to the said Erastus B. Kunkle, defendant, commanding him on a day therein named to be and appear in this honorable court, and then and there to answer all and singular the premises, and to stand to and abide such further order or decree as shall be entered herein, &c.

THE CONSOLIDATED SAFETY VALVE COMPANY,
CHAS. A. MOORE, *Pres't & G. M.*

STATE OF ILLINOIS, }
Cook County, } ss:

Charles A. Moore, being first duly sworn on oath, says that he is the president of the Consolidated Safety Valve Company, the complainant in the foregoing bill of complainant, that he has heard read the said bill, and knows the contents thereof; that the same is true of his own knowledge, except as to matters and things therein stated on information and belief, and as to those matters he believes them to be true, and further he says not.

CHAS. A. MOORE.

9 Subscribed and sworn to before me, this 4th day of October, A. D. 1880.

[SEAL.] ROBERT L. TATHAM,
Notary Public.

R. L. TATHAM,
Solicitor for Complainant,
THOMAS WM. CLARKE,
of Boston, Mass., of Counsel.

Endorsed: Filed Oct. 6, 1880. W. H. Bradley, clerk.

On the same day, to wit, on the sixth day of October, A. D. 1880, there issued out of said clerk's office a writ of subpœna in said entitled cause, which said writ, together with the return of the marshal thereto attached, is in the words and figures following, to wit:

Subpœna.

UNITED STATES OF AMERICA, }
Northern District of Illinois, } ss:

The United States of America to Erastus B. Kunkle, Greeting:

We command you that you appear before our judges of our circuit court of the United States of America for the northern district of Illinois, at Chicago, in said district, on the first Monday in
10 the month of November next, to answer the bill of complaint of the Consolidated Safety Valve Company, this day filed in

the clerk's office of said court, in said city of Chicago, then and there to receive and abide by such judgment and decree as shall then or thereafter be made, upon pain of judgment being pronounced against you by default.

To the marshal of the northern district of Illinois to execute.

Witness the Hon. Morrison R. Waite, Chief Justice of the Supreme Court of the United States of America, at Chicago, aforesaid, this 6th day of October, in the year of our Lord one thousand eight hundred and eighty, and of our Independence the 105th.

[SEAL.] W. H. BRADLEY, *Clerk.*

Memorandum.

The above-named defendant is notified that unless he shall enter his appearance in the clerk's office of said court at Chicago, aforesaid, on or before the day to which the above writ is returnable, the complainant's bill will be taken against him as confessed, and a decree entered accordingly.

W. H. BRADLEY, *Clerk.*

Special Deputy's Return.

UNITED STATES OF AMERICA, }
Northern District of Illinois, } ss:

11 Know all men by these presents that I have appointed and by these presents do appoint Thomas Wing my true and lawful deputy to execute the annexed writ, Consolidated Safety Valve Co. *vs.* Erastus B. Kunkle, and to make return of the execution thereof according to law.

JESSE S. HILDRUP, [SEAL,]
United States Marshal for the Northern District of Illinois.

I have served the annexed writ in the following manner, to wit, by delivering a true copy thereof to Erastus B. Kunkle therein named, on the 6th day of October, A. D. 1880.

JESSE S. HILDRUP,
United States Marshal,
By THOS. WING, *Special Deputy.*

Thomas wing, being duly sworn, deposes and says that he served the annexed writ as stated in the foregoing return, and that the expense returned by him in addition to the fees was actually incurred, and that the same is according to law.

Sworn to before me, this sixth day of October, A. D. 1880.

[SEAL.] PHILIP A. HOYNE,
United States Commissioner for the Northern District of Illinois.

Endorsed: Filed Oct. 8, 1880. Wm. H. Bradley, clerk.

12 Afterwards, to wit: On the first day of November, A. D. 1880, came the defendant, by his solicitor, and filed in said

clerk's office his appearance in said entitled cause, which said appearance is in the words and figures following, to wit:

Appearance.

United States Circuit Court, Northern District of Illinois. In Chancery.

THE CONSOLIDATED VALVE COMPANY
vs.
ERASTUS B. KUNKLE.

I hereby enter my appearance as solicitor and of counsel for the defendant in the above-entitled cause.

J. H. RAYMOND.

Chicago, Illinois, 1st November, 1880.

Endorsed: Filed Nov. 1, 1880. Wm. H. Bradley, clerk.

Afterwards, to wit, on the fifteenth day of November, A. D. 1880, came the complainant, by its solicitor, and filed in said clerk's office its amended bill in said entitled cause, which said amended bill is in the words and figures following, to wit:

Amended Bill.

13 UNITED STATES OF AMERICA, } ss:
Northern District of Illinois, }

In the Circuit Court of the United States for said Northern Distrtct of Illinois. In Chancery.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE.

Amendments to the bill of complaint filed in the above-entitled cause, made pursuant to an order of said court, entered on the 15th day of November, A. D. 1880.

First. In the 21 line of the 4 page of said bill of complaint after the words "more fully and at large appears," insert the following, to wit: "And your orator further shows unto your honor that heretofore, to wit, on the 8th day of September, A. D. 1868, one E. H. Ashcroft, who was then, and still is, a citizen of the United States, became, and was, the true and original inventor of a certain other improvement in steam safety valves; and thereupon, after due proceedings had, according to law, letters patent of the United States were duly issued for said invention to said E. H. Ashcroft, the inventor of said last-mentioned improvement in steam-safety valves by the Commissioner of Patents of the United States, which
14 said letters patent bear date the eighth day of September, A. D. 1868, and are numbered 81863, as will appear by said original letters patent, which your orator is ready to produce upon a hearing of this cause.

And your orator further shows unto your honor that heretofore, to wit, on the 19th day of January, A. D. 1869, one George William Richardson, who was then a resident of the State of New York and a citizen of the United States, became, and was, the true, first, and original inventor of a certain other improvement in steam safety valves; and thereupon, after due proceedings had, according to law, letters patent of the United States were duly issued for the said last-mentioned invention to said George William Richardson by the Commissioner of Patents of the United States, which said last-mentioned letters patent bear date the nineteenth day of January, 1869, and are numbered 85963, as will more fully appear by said original letters patent ready to be produced in court by your orator on a hearing of this cause.

And your orator further represents unto your honor that the title to said last-mentioned letters patent numbered 81863 and 85963, became vested in your orator by assignment from said E. H. Ashcroft and George William Richardson, respectively, prior to
15 the first day of January, A. D. 1880, and that your orator is now the sole and exclusive owner thereof, and, as such owner, is entitled to all the rights and privileges under said two last-named letters patent.

R. L. TATHAM,
Solicitor for Complainant.

It is hereby stipulated & agreed by the solicitors for the respective parties that the foregoing amendment to the bill shall be filed and said bill so amended by mutual consent.

November 15th, 1880.

R. L. TATHAM.
Sol'r for Compl't.
J. H. RAYMOND,
Sol'r for Def't & of Counsel.

Endorsed: Filed Nov. 15th, 1880. Wm. H. Bradley, cl'k.

Afterwards to wit, on the twenty-fifth day of January, A. D. 1881, came the defendant by his solicitor and filed in said clerk's office his answer to the bill of complaint in said entitled cause, which said answer is in the words and figures following to wit:

16 *Answer*

United States Circuit Court, Northern District of Illinois. In Equity.

THE CONSOLIDATED SAFETY VALVE COMPANY
v.
ERASTUS B. KUNKLE.

Answer of the said defendant, Erastus B. Kunkle, to the bill of complaint of the said complainant, The Consolidated Safety Valve Company.

The defendant now and at all times saving and reserving to him-

self all manner of benefit and advantage of exception to the manifold errors and insufficiencies in said bill of complaint contained for answer thereto, or to so much and such parts thereof as this defendant is advised is material to be answered, says:

First. That this defendant is ignorant whether or not the said complaint be a corporation duly organized, &c., as in said bill is alleged, and leaves the complainant to its proof thereof.

Second. That this defendant is not informed, save by said bill of complaint, and therefore cannot either admit or deny whether due proceedings were had according to law by the said George William Richardson and the said E. H. Ashcroft, and whether the terms of the statutes in such case made and provided were complied
17 with by them, and whether pursuant thereto letters patent of the United States, bearing date the 25th day of September, A. D. 1866, and numbered 58294, the 8th day of September, A. D. 1868, and numbered 81863, and the 19th day of January, A. D. 1869, and numbered 85963, were respectively duly issued and whether prior to the 1st day of January, A. D. 1880, the title to said letters patent and each of them became vested in the complainant, and whether said complainant is now the sole and exclusive owner thereof, and of the right to recover for infringements thereof heretofore committed, and whether the alleged invention described and claimed in said letters patent, numbered 58294, is of great value or has come into general and extensive use, but as to all matters pertaining to the obtaining and granting of said letters patent and each of them and to the assignments thereof, and to the value and the use or public practice of the alleged invention described and claimed in said letters patent numbered 58294 this defendant insists upon full and strict proof.

Third. That this defendant is ignorant of the alleged adjudication and judgment concerning the said letters patent numbered 58294 in the circuit court for the district of Massachusetts, in a cause therein heretofore pending, as alleged, between the said Richardson and one Edward H. Ashcroft, and so to each and all the proceedings, pleadings, and proofs of the said case; and as to all matters pertaining to said alleged suit and judgment, this defendant insists upon
18 full and strict proof.

Fourth. That the defendant is informed and advised, and therefore upon information and belief alleges, that the issues of the said alleged suit were not the same as the issues of this present suit, but that material and additional defenses will be relied upon by this defendant in this suit; and further, that this defendant was not in any manner a party to the said suit or judgment, and that he was not represented or heard therein.

Fifth. That this defendant denies that the said George William Richardson was the first and original inventor of the said pretended improvement described and claimed in the said alleged letters patent numbered 58294 of 1866, or any material or substantial part thereof, but alleges that the same, or the material or substantial parts thereof were invented and patented prior to the said Richardson's pretended invention thereof.

By Charles Ritchie, of Aberdeen, Scotland, August 3d, 1848, by letters patent issuing from the Great Seal Patent Office in England, numbered 12078.

By James Webster, of Birmingham, England, July 12th, 1857, by letters patent issuing from the Great Seal Patent Office in England, numbered 1955.

By William Hartley, of Bury, England, August 19th, 1857, by letters patent issuing from the Great Seal Patent Office in England, numbered 2205.

By William Naylor, July 21st, 1863, by letters patent issuing from the Great Seal Patent Office in England, numbered 1830.

By Charles Beyer, April 25th, 1863, by letters patent issuing from the Great Seal Patent Office, in England.

By Henry Waterman, by letters patents issued by the United States, and bearing date November 15th 1853, and

By H. P. M. Birkenbone, by letters patent issued by the United States, and bearing date March 27th, 1866.

Sixth. That the said Richardson was not the first and original inventor of the alleged improvements described in the said alleged letters patent, numbered 58294 of 1866, or of any substantial or material parts thereof, but that the same or substantial and material parts thereof were described prior to the said pretended invention thereof by the said Richardson in printed publications issued by the Great Seal Patent Office, in England, as copies of the specifications of the said letters patent issued from the said office hereinabove in the last paragraph referred to, of duly authenticated copies of which this defendant makes profert; and further, in a printed publication, issued in England, June 1st and July 1st, A. D. 1858, called "The Artizan," commencing at pages 148 and 173 respectively, communications of Richard Roberts and Charles Ritchie.

Seventh. That this defendant is informed, and therefore upon information and belief alleges, that the said pretended improvements described and claimed in the said letters patent numbered 58294 of 1866 were abandoned to the public by the said Richardson long prior to any application by him for letters patent thereon.

Eighth. That this defendant denies that the said E. H. Ashcroft was the first and original inventor of the said pretended improvements described and claimed in the said alleged letters patent numbered 81863 of 1868, or any material or substantial part thereof, but alleges that the same, or the material and substantiail parts thereof, were invented and patented prior to the said Ashcroft's pretended invention thereof by the following persons by letters patent of the United States numbered and issued as follows: Number 54716 to V. D. Green, 15th May, 1866; number 56409 to E. Hamilton, 17th July, 1866; number 21535 to Hardy & Parkieson, 14th September, 1858; number 62722 to J. Zundorff, 5th May, 1867; number 81167 to H. W. Hewitt, 18th, August 1868. And that the same, or substantial and material parts thereof, were prior to the said Ashcroft's pretended — thereof, described and shown in printed publications issued by the Great Seal Patent Office, in England, as copies of the

specifications of letters patent granted as follows: Number 756 to Watts, 23rd March, 1860, and number 2743 to Clayton and Shuttleworth, 3rd December, 1859.

Ninth. That this defendant denies that the said Richardson was the first and original inventor of the said pretended improvements described and claimed in the said alleged letters patent numbered 85963 of 1869, or of any material and substantial part
21 thereof, but alleges that the same, or material or substantial parts thereof, were invented and patented prior to the said Richardson's pretended invention thereof.

By Charles Ritchie, of Aberdeen, Scotland, August 3rd, 1848, by letters patent issuing from the Great Seal Patent Office, in England, numbered 12078.

By James Webster, of Birmingham, England, July 12th, 1857, by letters patent issuing from the Great Seal Patent Office, in England, numbered 1955.

By William Hartley, of Bury, England, August 19th, 1857, by letters patent issuing from the Great Seal Patent Office, in England, numbered 2205.

By William Naylor, July 21st, 1863, by letters patent issuing from the Great Seal Patent Office, numbered 1830.

By Charles Beyer, April 25th, 1863, by letters patent issuing from the Great Seal Patent Office, in England, numbered 1038.

By Thomas Green, November 9th, 1859, by letters patent issuing from the Great Seal Patent Office, in England.

By Henry Waterman, by letters patent issued by the United States and bearing date November 15th, 1853.

And by the following persons, by letters patent of the United States numbered and issued as follows:

Number 10012, issued to C. H. Mann, 13th September, 1853.
" 15376, " J. Humphrey, 22nd July, 1856.
" 18103, " J. H. Powers, 1st September, 1857.

22 And, further, that the said alleged improvements described and claimed in said letters patent number 85963, of 1869, or material and substantial parts thereof, were shown and described prior to the said pretended invention thereof by the said Richardson, in printed publications issued by the Great Seal Patent Office, as copies of the specifications of the first six letters patent in this ninth paragraph named, of duly authenticated copies of which this defendant makes profert.

Tenth. This defendant, further answering, says that he has never made any steam safety valves, or caused the same to be made, in the city of Chicago, or anywhere in the said northern district of Illinois, and that he has not, at the said city of Fort Wayne or elsewhere, made, used, or sold to others to be used, great numbers, or any number whatever, of steam safety valves involving the said alleged inventions described and claimed in the said letters patent, respectively, in said bill of complaint alleged to be owned by the said complainant, to the damage of said complainant, or in fraud of any of its rights; and the said defendant further denies that he has in any way or manner infringed, and that he is in any way or manner

infringing, and that he intends or purposes in any way or manner to infringe, the said letters patent, or either of them, or the said complainant's alleged rights thereunder; but the said defendant alleges that he was the first and original inventor of certain
23 improvements in steam safety valves, for which letters patent of the United States were granted to him the 4th day of May, 1875, numbered 162,831, and on the 24th day of July, 1871, numbered 193,411; and that all the right, title, and interest in, to, and under said letters patent is now vested in him, the said defendant, and that for —— years last past he has been manufacturing and selling steam safety valves for locomotive and stationary engines, under said letters patent, but not in strict accordance therewith; but this defendant again and specifically denies that any steam safety valves so made or so sold by him was an infringement upon either of the said letters patent upon which this suit is brought.

Eleventh. That this defendant denies that the said complainant is entitled to any further answer from this defendant, or to any relief in the manner or form as prayed by it in the said bill of complaint.

All which matters and things this defendant is ready to aver, maintain, and prove, as this honorable court shall direct, and humbly prays to be herein dismissed with his reasonable costs in this behalf most wrongfully sustained.

ERASTUS B. KUNKLE,
By J. H. RAYMOND,
His Solicitor & Counsel.

Endorsed: Filed Jan. 25, 1881. W. H. Bradley, cl'k.

24 Afterwards, to wit, on the 27th day of January, A. D. 1881, came the complainant by its solicitor and filed in said clerk's office its replication to the answer of the defendant in said entitled cause; which said replication is in the words and figures following, to wit:

Replication.

UNITED STATES OF AMERICA, } *ss*:
Northern District of Illinois, }

In the Circuit Court of the United States for said Northern District of Illinois. In Chancery.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE.

The replication of the Consolidated Safety Valve Company, complainant, to the answer of Erastus B. Kunkle, defendant.

This repliant, saving and reserving unto itself all and all manner of advantage of exception to the manifold insufficiencies of the said answer, for replication thereunto, says: That it will aver and prove its said bill to be true, certain, and sufficient in the law to be an-

swered unto, and that the said answer of the defendant is uncertain, untrue, and insufficient to be replied unto by this repliant, without this, that any other matter or thing whatsoever in said answer
25 contained material or effectual in law to be replied unto, confessed and avoided, traversed or denied, is true; all which matters and things this repliant is and will be ready to aver and prove as this honorable court shall direct, and humbly prays as in and by its said bill it has already prayed.

R. L. TATHAM,
Solicitor for Complainant.

Endorsed: Filed Jan'y 27, 1881. W. H. Bradley, c'l'k.

Afterwards, to wit, on the fourth day of May, 1881, came the complainant, by its solicitor, and filed in said clerk's office its motion for a preliminary injunction in said entitled cause; which said motion is in the words and figures following, to wit:

Motion.

UNITED STATES CIRCUIT COURT, } *ss:*
Northern District of Illinois, }

THE CONSOLIDATED SAFETY VALVE CO. }
vs. } In Chancery.
ERASTUS B. KUNKLE. }

And now comes the Consolidated Safety Valve Company, complainant in the above-entitled cause, by R. L. Tatham, its
26 solicitor, and moves the court for a preliminary injunction in said cause as prayed for in the bill of complaint filed herein, and in accordance with the rules and practice of courts of chancery in like causes.

R. L. TATHAM,
Solicitor for said Complainant.

Endorsed: Filed May 4, 1881. Wm. H. Bradley, c'l'k.

On the same day, to wit, on the fourth day of May, in the adjourned May term of said court, A. D. 1881, in the record of the proceedings thereof in said entitled cause, before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Order.

CONSOLIDATED SAFETY VALVE COMPANY }
vs. } In Chancery.
ERASTUS B. KUNKLE. }

Now come the parties, by their solicitors, and now comes on to be heard the motion of the complainant for a preliminary injunction herein; and the court, after hearing the same in part, the further hearing of the same is postponed until to-morrow morning.

27 Afterwards, to wit, on the fifth day of May, in the adjourned May term of said court, A. D. 1881, in the record of the pro-

ceedings thereof in said entitled cause, before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Order.

CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

Now come again the parties, by their solicitors, and after concluding the hearing upon the motion of the complainant for a temporary injunction herein, the court sustains said motion, and grants said injunction as prayed for, unless defendant shall within twenty days give bond in the penal sum of three thousand dollars, conditioned for the payment of all damages recovered against him herein.

And thereupon time for taking proofs herein is extended ninety day, by agreement of the parties.

Afterwards, to wit, on the twenty-fourth day of May, A. D. 1881, there was filed in said clerk's office an injunction bond in said entitled cause, which said bond is in the words and figures following, to wit:

28 *Bond.*

United States Circuit Court, Northern District of Illinois.

CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

Know all men by these presents, that we, Erastus B. Kunkle as principal, and Charles McCulloch and Frederick Eckert as surety, and each of us are held and firmly bound unto the Consolidated Safety Valve Campany of Connecticut, in the penal sum of three thousand (3,000) dollars well and truly to be paid, to which we and each of us hereby bind ourselves, our heirs, executors, and administrators.

The condition of this obligation is such, nevertheless, that whereas there is now pending in the circuit court of the United States for the northern district of Illinois a suit in chanceay for the alleged infringement of certain letters patent of the United States, granted respectively in 1866 and 1869, to George William Richardson, in which the said Consolidated Safety Valve Company is complainant, and the said Kunkle is defendant—

Now, therefore, if the said Kunkle or his legal representatives shall answer, satisfy, and pay any final decree which at the
29 end of said litigation may be entered against him, then this obligation to be null and void, but otherwise to remain in full force and effect.

Witness our hands and seals this 12th day of May, 1881.
ERASTUS B. KUNKLE.
CHARLES McCULLOUGH.
FRED. ECKERT.

Approved:
H. W. BLODGETT, *Judge.*

Endorsed: Filed May 24, 1881. Wm. H. Bradley, cl'k.

Afterwards, to wit, on the twenty-fifth day of October, in the adjourned October term of said court, A. D. 1882, in the record of the proceedings thereof in said entitled cause before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Order.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

On motion of Mr. Raymond for the defendant, leave is hereby given to amend the answer herein.

30 Afterwards, to wit, on the first day of November, in the adjourned October term of said court, A. D. 1882, in the record of the proceedings thereof in said entitled cause, before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Order.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

Now comes the parties, by their solicitors, and on motion of the defendant, by his solicitor, and as per stipulation filed herein, leave is given said defendant to amend his answer herein, and this cause being set down for hearing upon the pleadings and proofs and the arguments of counsel being now heard in part, the further hearing thereof is postponed till to-morrow morning.

On the same day, to wit, on the first day of November, A. D. 1882, came the defendant, by his solicitor, and filed in said clerk's office his amended answer in said entitled cause, which said amended answer is in the words and figures following, to wit:

Amended Answer.

United States Circuit Court, Northern District of Illinois.

31 CONSOLIDATED SAFETY VALVE CO.
vs.
ERASTUS B. KUNKLE. } In Chancery.

This defendant, further answering, says that the said letters

patent of 1869, numbered 85963, were illegally issued, and are null, void, and of no effect in law, for this that the said Richardson, the alleged inventor, etc., as in said bill of complaint set forth, did not in the specifications of said letters patent, number 85963, particularly point out and distinctly claim the part, improvement, or combination which he claims as his invention or discovery.

J. H. RAYMOND,
Def't's Sol'r & of Counsel.

Endorsed: Filed Nov. 1, 1882. Wm. H. Bradley, clerk.

Afterwards, to wit, on the second day of November, in the adjourned October term of said court, A. D. 1882, in the record of the proceedings thereof in said entitled cause, before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Order.

CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

32 Now come the parties by their solicitors, and the remaining arguments of counsel in this cause being now heard and concluded, and the court not being sufficiently advised in the premises takes the same under further advisement.

Afterwards, to wit, on the eighth day of January, in the December term of said court, A. D. 1882, in the record of the proceedings thereof in said entitled cause, before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Decree.

CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

Now come the parties by their solicitors, and the court having considered the pleadings and proofs and the arguments of counsel submitted herein, and being now fully advised in the premises, finds that the defendant does not infringe the complainant's patent as claimed in the bill of complaint herein. It is thereupon ordered and decreed that said bill be dismissed at complainant's costs, and that execution issue therefor.

And now comes the complainant, by its solicitor, and prays
33 an appeal herefrom to the Supreme Court of the United States, which is allowed upon its giving bond in the penal sum of one thousand dollars, to be approved by the court.

On the same day, to wit, on the eighth day of January, A. D. 1883, Judge Blodgett filed in said clerk's office his opinion in said entitled cause, which said opinion is in the words and figures following, to wit:

34 *Opinion of Judge Blodgett.*

Circuit Court of the United States, Northern District of Illinois.

THE CONSOLIDATED SAFETY VALVE CO.
vs.
ERASTUS B. KUNKLE.

Blodgett, *J.:*

This is a suit to enjoin the alleged infringement by defendant of two patents issued to George W. Richardson, one, No. 58,294, dated September 25, 1866, for an "Improvement in Safety Valves," and the other, No. 85,963, dated January 19, 1869, for an "Improvement in Safety Valves."

The defenses relied upon are:

1st. That defendant does not infringe.

2d. That complainant's patents are void for want of novelty and for uncertainty in the specifications and claims.

The peculiar feature of these two patents is what is termed by the experts the stricture, the operation of which is to secure an additional lifting force on the head of the valve beyond that of the initial pres-ure inside of the steam generator; and the second patent, which purports to be an improvement on the first, has an arrangement by which this stricture is made adjustable by a peculiar device
35 which is minutely described. These patents have been several times before the courts, and so far considered in the light of the state of the art as to very much abridge the area for discussion or construction in this case.

In Ashcroft *vs.* Boston & Lowell Railroad Company, reported in 1st Banning and Arden 215, and in Richardson *vs.* Ashcroft, not reported, the contest was between the Richardson patent and the Naylor patent, issued in England in July, 1863, and in this country in 1866, a month or two after the first Richardson patent, and Judge Shepley, before whom these cases were heard, held in the first-named case that the Richardson device did not infringe the Naylor patent, and in the second case, that the Naylor patent did not infringe the Richardson.

The Naylor patent was for a safety valve, constructed with an extended area upon the head of the valve for the purpose of aiding in the lift, and in that respect it was claimed that Richardson infringed upon Naylor.

Judge Shepley, in his opinion in the first mentioned case, says:

"Without adverting to the patents of Hartly, Waterman, and other devices older than Naylor's, we have seen that Naylor could not with propriety claim to have been the inventor of the combination in a spring safety valve of every form of projecting, overhanging, downward-curved-lip or periphery, with an annular recess surrounding the valve-seat into which a portion of the steam is directed as it issues between the valve and its seat." * * *
36 "Naylor did not invent the overhanging, downward-curved-lip or periphery, nor was he the first to use an annular chamber surrounding the valve-seat, into which a portion of the steam is

deflected as it issues between the valve and its seat. His claim must, therefore, be limited to the combination of the other elements, with precisely such an annular recess as he has described, and operating in the described manner, so far as such recess separately or in combination differed in construction and operation (if it did materially differ in those respects from those which had preceded it). The claims cannot be made to cover a safety-valve like the Richardson valve, which, in its construction and mode of operation, is substantially different from the valve described in the Naylor patent, simply because the Richardson valve, in common with the Naylor valve, has the overhanging, downward-curved-lip or periphery, and an annular recess surrounding the valve-seat into which a portion of the steam issuing from between the valve and its seat is deflected. The differences between the Richardson and Naylor valves in construction are apparent upon an inspection of the drawings in the respective patents. The difference in the mode of operation is most clearly proved by the testimony of experts in the case. In the Naylor valve it appears that it was the intention of the inventor to use the impact of the issuing steam upon the concave lip of the valve to assist in lifting it, and only this, so far as it was aided by the diminution of the atmospheric pressure on the top of the valve, consequent upon the issuing of a portion of the steam in an upward direction around the periphery of the valve; the annular chamber, into which the steam is discharged on leaving the valve, serving no other purpose than that of a conduit for the steam, when the valve is constructed in accordance with the drawings in the original patent. In the Richardson valve, when the valve opens, the steam expands and flows into the annular space around the ground joint. Its free escape is prevented by a stricture or narrow space formed by the outer edge of the lip and the valve seat. Thus the steam escaping from the valve is made to act by its expansive force upon an additional area outside of the valve proper, to assist in raising the valve, this structure being enlarged as the valve is considerably lifted from its seat, and varying in size as the quantity varies of the issuing steam. There would be no such variable stricture in the Naylor valve."

37

This case went to the Supreme Court of the United States, and in its opinion, affirming the case, the court says: "Taken as a whole, the facts show conclusively that the assignor of the complainant (Nailor) was not the first person to devise means for using the recoil action of steam to assist in lifting the seat of the steam valve for the purpose described, and it follows that the patentee in suit must be limited to what he actually invented, which is the devices shown in the specifications and drawings, to enable the party to avail himself of such recoil action." * * * *

38

"Coming to the specification that describes the steam valve used by the respondents (Richardson's), it will at once be seen that its construction and mode of operation is substantially different in important particulars, as follows:

"When the valve opens, the steam expands and flows into the annular space around the ground joint. Its free escape, which

might otherwise be too free, is prevented by a stricture or narrow space formed by the outer edge of the lip and the valve seat. By these means the steam escaping from the valve is made to act by its expansive force upon an additional area outside of the device, as ordinarily constructed, to assist in raising the valve, the stricture being enlarged as the valve is lifted from its seat, and varying in size as the quantity of the issuing steam increases or diminishes. Important functions, not very dissimilar in the effect produced, are performed by the two patented valves in controversy; but the means shown in the respective specifications and the mode of operation described to produce the effect are substantially different in material respects, which shows to a demonstration that the complainants cannot prevail, unless it can be held that his assignor invented the overhanging downward-curved lip and that he was the first
39 to use an annular chamber surrounding the valve seat, into which a portion of the steam is deflected as it issues between the valve and its seat. Neither of those conditions can be found in favor of the complainant, and of course it cannot be held that the respondents have infringed his patent."

These patents were again before Judge Lowell, of the eastern district of Massachusetts, in a case where the present complainant sued the Crosby Valve Company for infringement, the opinion on the final hearing of the case having been delivered in April, 1881, and is made a part of the record in this case. In that opinion Judge Lowell says: "In this record the defendant introduces two English patents not brought out in Richardson *v.* Ashcroft, and I have examined two accomplished experts in relation to them. They also produce the American reissued patent of Waterman, which I suppose to have been before Judge Shepley, in connection with the state of the art, but which, if we may judge from the pleadings, was not relied on to defeat the novelty of the Richardson patent. The original patent of Waterman, which was considerably older than Richardson's patent, while claiming an improvement to a different part of the valve, showed a structure so much like Richardson's that Richardson sought out the inventor, and they made a joint stock of their two patents, and procured a reissue of that of Waterman, in which he specifies a mode of construction by which, when the
40 valve is raised from its seat, the escaping steam is so directed as to enter an overhanging or projecting annular chamber on the top or upper part of the valve, and outside of and beyond the ground joint. He describes how this force may be modified by a modification of the overhanging or projecting annular surface. He goes into all the details of the necessary and proper construction, and, in short, as I understand it, describes the Richardson valve, with a stricture and all, excepting that his additional lift was due wholly to the expansive power of the steam admitted to the annular chamber, while Richardson used both the impact of the issuing steam and its subsequent expansive power. Naylor had used the impact only." * * * *

"My opinion, based upon the issue of infringment, makes it unnecessary for me to explain at large the conclusions concerning the state

of the art at which I have arrived after a patient study of the record, excepting to this extent: I consider it to be fully proved that some valves had been made before 1866 which operated on the same general principle with that of Richardson, and were of some value. Especially is this true of the Naylor and Waterman contrivances, and probably of Beyer's." * * * *

"In this state of the art Richardson describes an annular chamber outside the ground joint of a valve, and so regulated by the crack, or operated between its lip and the main body of the valve that it will confine or 'huddle,' as the experts say, the steam, when
41 it begins to escape from the chamber, and will presently, afterwards, open more widely and let the steam escape, and not interfere with the rapid fall of the valve before it has lost too much steam."

The learned judge then particularly describes the Crosby device, the peculiarity of which is that when the valve rises an additional part of its under surface is exposed to the action of the steam in the chambers. This additional part is either masked or neutralized until the valve begins to rise, when it furnishes an additional lift proportioned to the additional area exposed, and concludes as follows: "Now it is plain that this contrivance does not come strictly within the language of the plaintiff's claim of a safety valve with the circular or annual lip, &c." * * * *
"Considering the state of the art as I have found it to be, that Richardson was not the first inventor, and apply more or less well the principle of the additional area, nor that of the stricture, he could not, whatever the words of his claim, successfully enjoin the use of a valve resembling his own only in its adoption of these general ideas."

The result of these judicial constructions upon the Richardson device, as I understand them, is to limit the Richardson patent to the special device therein shown for obtaining a common result. In other words, although Naylor showed an extended area of the valve head with a downward curved lip or flange, thereby producing
42 an annular chamber or recess by which the escaping steam was impeded in its progress to the open air, and an additional lifting force secured for raising the valve, and though Crosby showed an increased area of valve surface, upon which the steam began to press as soon as it commenced to escape through the ground joint, yet neither of these infringe the Richardson patents, because they are not just like Richardson's. They produce the same result, but each by a somewhat different mechanical appliance, and Richardson was not held entitled to invoke the doctrine of equivalents.

The defendant's valve shows an extended area of the valve head so as to form a flange and an extension of the valve seat upwards, so as to form a ring encircling and reaching above the extended valve head, so that the steam as it escapes through the ground joint impinges upon the flange of the valve head, and by its impact furnishes an auxiliary lift to aid in raising the valve still higher. The Kunkle valve shows also a screw ring attached to the valve seat, and so arranged as to be movable up and down, thereby controlling to

some extent the direction of the escaping steam, and causing it to impinge more or less directly upon the flange of the valve head. But in the light of the testimony, and especially of the series of interesting and instructive experiments made by Mr. Hoadley, the defendant's expert witness, with defendant's valve in comparison with the Richard-
son, Webster, Hartly, and Waterman valves, I fail to find in de-
43 fendant's valve the stricture which is shown in and especially provided for by the Richardson valve. There may be some stricture, that is, the steam may be to some extent huddled, and compelled to exert its expansive force on the under side of the extended area of the valve-head, by means of the crooked or angular passages through which it makes its exit to the open air; but a stricture as such was not the invention of Richardson. Mr. Forbes, complainant's expert, finds the stricture in the Webster patent, and one in Ritchies', to such an extent that it can readily be converted into the Richardson valve by slightly reducing "the periphery of the supplemental flange;" and Richardson himself, in the Waterman reissue, must be held to have assented to the claim that the Waterman valve shows a stricture, while the Beyer, Hartly, Greene, and Naylor valve also show that the steam in its escape must be to some extent impeded, and thereby compelled to exert some expansive force upon the supplemental areas of their respective valves.

While in Richardson's valve the expansion of the steam in the annular chamber, made by the downward curved lip, is the chief factor relied upon for an increase of lifting force, and this annular expansion chamber acting in conjunction with the stricture or throttle-escape, passage for the steam from the expansion chamber is the peculiar feature of Richardson's device.

Webster, it seems to me, shows not only a stricture, but the
44 element of adjustability is clearly shown by the provision for raising or lowering the auxiliary plate or flange upon the spindle of the valve, so as to increase or diminish the opening for the escape of the steam from beneath the extended area of the supplemental flange.

I am certainly unable to find in Kunkle's valve such a stricture as is specially described by Richardson in his patent of 1869. On the specifications of that patent he says: "The said means so patented" (referring to his patent of 1866), "consisting in forming the valve with a surface outside of the ground joint for the escaping steam to act against, the said surface being surrounded by a projecting lip, rim, or flange, leaving a narrow space for the escape of the steam when the valve is open but which, although of greater diameter than the valve seat by reason of the said lip, presents a less area of opening for the escape of steam than is produced at the valve seat; so that the steam which escapes through the area between the valve shall exert pressure between the said surrounding surfaces, and thereby not only open the valve completely, but hold it up until the pressure of the steam in the boiler falls below the pressure by which the valve was opened."

This, as I understand it, is Richardson's definition of the construction and operation of his stricture, and requires, in specific

terms, that the space for the escape of the steam between the
45 flange and ring encircling the expanded valve head shall be
of less area than the area of escape at the valve seat, a peculiarity not provided for in Kunkle's valves, and evidently not intended to be a part of his mechanism, as from the time the steam passes through the ground joint of the Kunkle valve it is nowhere throttled and compelled to pass through a less area on its way to the open air, its exit passages increasing constantly in area, instead of diminishing. With strictures shown in the older stages of the art, I am therefore clearly of the opinion that Richardson must be confined to his special mode of producing the stricture; and I am also of opinion that whatever of stricture the defendants show is more nearly, in the mechanical mode of producing it and in its operation, like the older devices of Beyer, Hartley, Webster, Greene, Waterman, and Naylor. It is true the defendant uses a screw ring in his valve, and that Richardson in his patent of 1869 shows a screw ring; but the screw ring shown in the defendant's device is not, in its function nor relation to the operation of the defendant's patent, the same as the screw ring of the complainant's device of 1869. The complainant's screw ring was intended specifically to operate as a stricture or to regulate the size of the opening for the escape of the steam, a duty which is not performed by the defendant's ring. The claim of Richardson in the patent of 1869 is "for a combination of the surface beyond the seat of the safety valve with the means herein described for regulating or adjusting the area of the passage for
46 the escape of steam, substantially as and for the purpose described."

The specifications describe minutely the means for regulating or adjusting the "area of the passage for the escape of steam" to be by the operation of a screw ring in connection with a central aperture and the disk *f*. Here was a peculiar method of throttling or holding the steam so as to make its expansive force available as an auxiliary to help lift the valve, and the claim covers only that special combination.

A new outlet for the steam inside of the outlet between the expanded head of the valve and its extended seat is provided in Richardson's later patent, and his claim must be held to cover only that peculiar mechanism by which the new outlet is provided, and its function determined in combination with the other parts of his device.

After Webster had taught the world how to regulate the escape of the steam by his movable plate upon a spindle on the valve head, and to hold it at the proper point of adjustment by the set screw, Kunkle was, it seems to me, at liberty to regulate the opening for the escape of the steam by means of a screw ring upon the periphery of the valve seat, or by placing such a ring upon the extended valve head, if he saw fit to do so. The idea of so regulating even the size of the stricture by a movable plate is older than Richardson's invention, and was public property when his invention was made.

47 I will add, that from the experiments made by the experts in this case, as shown in the proof, it seems quite probable to

me that the improved practical results obtained by the Richardson and Kunkle valves over those previously in use is as much attributable to their improved finish and mechanical perfection as to any newly invented element they contain.

In the hands of a skilful manipulator valves constructed according to the specifications of the Webster and Hartley patents, including the proportions given in that patent, did their work substantially as well as the Richardson and Kunkle valve. The Webster, Hartley, and Waterman valves, when mechanically well made, showed results closely approximating to the best results of Richardson's device. It was long after the steam engine was a complete conception in the mind of Watt before skilled workmen were trained by experience and in the use of suitable tools to make it accomplish what he intended and theoretically knew it was capable of doing. So these old English and American valves, intended to work on substantially the same principle as Richardson's, may have failed for lack of skill in making and using them rather than because their inventors had not conceived the true principle upon which they were to work. The bill must be dismissed, because I find under the proof the defendant does not infringe the plaintiff's patent.

Endorsed: Filed Jan'y 8, 1883. Wm. H. Bradley, clerk.

48 Afterwards, to wit, on the seventh day of March, in the adjourned March term of said court, A. D. 1883, in the record of the proceedings thereof in said entitled case, before Hon. Henry W. Blodgett, district judge, is the following entry, to wit:

Order.

CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Chancery.

On motion of complainant's solicitor the time allowed it for filing an appeal bond herein is hereby extended fifteen days.

49 Afterwards, to wit, on the eighth day of March, A. D. 1883, there was filed in said clerk's office an appeal bond in said entitled cause, which said appeal bond is in the words and figures following, to wit:

Appeal Bond.

Supreme Court of the United States.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE.

Know all men by these presents that we, The Consolidated Safety Valve Company, of Boston, Massachusetts, and Samuel W. Adams, of the city of Chicago, Cook county, Illinois, are held and firmly bound unto Erastus B. Kunkle, of the city of Ft. Wayne, Indiana, in the sum of one thousand dollars, to be paid to the said Erastus

B. Kunkle, his executors or administrators, to which payment well and truly to be made we bind ourselves and each of us jointly and severally and our and each of our successors, heirs, executors, and administrators firmly by these presents.

Sealed with our seals. Dated this 6th day of March, 1883.

Whereas the above-named, The Consolidated Safety Valve Company, hath taken an appeal to the Supreme Court of the United
50 States to reverse the decree rendered in the above-entitled action by the circuit court of the United States for the northern district of Illinois—

Now, therefore, the condition of this obligation is such that if the above-named the Consolidated Safety Valve Company shall prosecute its appeal to effect, and answer all costs and damages if it shall fail to make good its plea, then this obligation shall be void, otherwise to remain in full force and virtue.

THE CONSOLIDATED SAFETY VALVE CO.
By CHAS. A. MOORE, *President.*
SAMUEL W. ADAMS.

Sealed and delivered in presence of, as to Charles A. Moore,
J. KNOX BURTON.

CITY AND COUNTY OF NEW YORK, *ss:*

On this 6th day of March, 1883, before me personally came Charles A. Moore, the president of the Consolidated Safety Valve Company, with whom I am personally acquainted, who being by me duly sworn, said that he resided in the city of Brooklyn, State of New York, that he was president of the Consolidated Safety Valve Company, and that he signed the corporate name of the Consolidated Safety Valve Company to the within instrument by order of the board of directors of said company for the purposes therein mentioned.

[SEAL.] J. KNOX BURTON,
Notary Public (172) *N. Y. Co.*

51 Approved:
H. W. BLODGETT, *Judge.*

Endorsed: Filed March 8, 1883. Wm. H. Bradley, clerk.

52 *Stipulation.*

UNITED STATES OF AMERICA, *Northern District of Illinois:*

In the Circuit Court of the United States for the Northern District of Illinois.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE. } In Equity.

It is hereby stipulated by and between the parties to the above entitled cause that upon any hearing in said cause the complainant and defendant may read in evidence or refer to any part of or all of the ex-

hibits, specifications, affidavits, and depositions contained in a bound volume hereto attached and entitled on its back, "Circuit court of the U. S., district of Massachusetts. In equity. Consolidated Safety Valve Company, complainants, *v.* Crosby Steam Gage and Valve Company, defendants, pleadings and evidence," with the same force and effect as if said matters contained in said bound volume were regularly and legally taken as competent evidence in this cause.

Chicago, Illinois, February 5th, 1881.

R. L. TATHAM,
Complainant's Solicitor.
J. H. RAYMOND,
Def't's Sol'r & of Counsel.

53 *Stipulation as to Complainant's prima facie Record.*

Circuit Court of the United States, Northern District of Illinois. In Chancery.

THE CONSOLIDATED SAFETY VALVE COMPANY
v.
ERASTUS B. KUNKLE.

It is hereby stipulated by and between the parties to the above entitled cause that the affidavits of George William Richardson, Charles A. Moore, and Charles W. Forbes, there being two affidavits of said Forbes therein contained in the printed papers of complainant on its application herein for a preliminary injunction, together with the exhibits referred to therein, shall be, and are hereby, made the complainant's *prima facie* case for the final hearing in this cause; the right of cross-examination of said witnesses upon the subject matter contained in said affidavits being hereby saved to the defendant, upon ten days' notice to the complainant or its solicitor to produce said witnesses, or any of them, for such cross-examination. And the defendant hereby admits the allegations in said bill of complaint herein heretofore filed, as to the due and legal incorporation of said complainant.

JAS. H. RAYMOND,
Solicitor and of Counsel for Defendant.
THOS. WM. CLARKE,
Of Counsel for Complainant.

New York, 10th September, 1881.

54 Circuit Court of the United States, Southern District of Illinois.

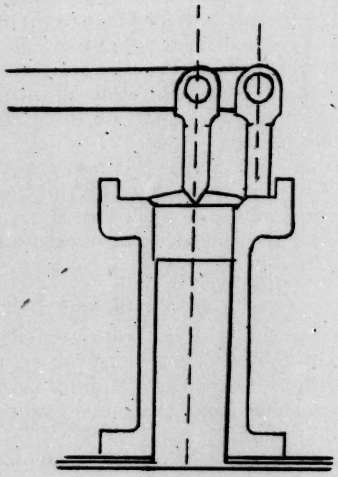
THE CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE.

Affidavit of Charles W. Forbes.

I, Charles W. Forbes, being duly sworn, on oath depose and say, that I am thirty-eight years of age; at present reside in Boston, Massachusetts, and am a mechanical engineer and an expert in patent causes.

PLATE I.

No. 547
Consolidated
Safety Valve Co.
v. page 56
Kunkle



The Common or Ordinary Safety Valve.

For the past twenty years I have been continuously engaged in various mechanical pursuits, and have been employed as a machinist in various manufacturing establishments, and particularly engaged in the construction and management of steam engines and boilers.

I was formerly in the employ of the Danforth Locomotive and Machine Works, at Paterson, New Jersey, and subsequently appointed an assistant engineer in the United States Navy; served at sea as such nearly four years, and have since filled the position of principal examiner in the United States Patent Office.

While occupying that position I was accustomed to compare descriptions, drawings, models, and machines, including contrivances using steam with each other, and others to which they related, and to which they were more or less similar.

After six years' experience in the United States Patent Office, I resigned the position of principal examiner, and during the past four years have been frequently called to testify as an expert in the courts of the United States.

I have examined, and understand, the inventions set forth in United States letters patent for improvement in safety valves granted to George W. Richardson, September 25, A. D. 1866, and January 19, 1869, and numbered respectively 58294 and 85963.

I am also familiar with the state of the art appertaining to safety valves as it existed at the time of the grant of the Richardson letters patent referred to.

In explaining the nature of these inventions I will first describe the construction and operation of the ordinary or common safety valve, and point out the objections to it, so that the present inventions, which are designed to overcome said objections, may be readily comprehended.

Common or Ordinary Safety Valve.

The ordinary safety valve, represented in Plate 1, consists of a circular disc of metal, bevelled inwardly at its periphery to form a face, which is designed to rest upon a corresponding bevelled seat, within an annular casing that surrounds the aperture in the shell of the boiler, to which it is secured.

Such valves have been loaded in various ways, to maintain them in their seats and permit them to open whenever the pressure in the boiler exceeded the load upon them—by a weight pressing directly upon them, by a spring acting directly upon them, and located either over or under them—or by such devices arranged in proximity to them and operating through intervening levers.

The direct acting spring, placed over the valve has been found, in practice, the best arrangement known for such purpose; the use of levers being attended with a possible derangement, inaccuracy of fit and consequent imperfection in the bearings of the several moving parts, which cause oblique strain and friction; and also by the accumulation of dirt were rendered unreliable, and in many cases inoperative.

(Here follows diagram, marked page 56.)

The defects experienced in the ordinarv safety valve, par-
57 & 8 ticularly when held in position by a direct acting spring, have long been understood; and the desirability of overcoming its defects has frequently been presented by eminent engineers.

The particular difficulty with the ordinary safety valve lies in its restricted range of action, due to the constantly increasing resistance of the spring when compressed, which prevents the valve from opening sufficiently wide to discharge the steam as fast as it is generated in the boiler, and causes a surplus pressue to accumulate in the boiler above that at which the valve is adjusted to open.

This danger cannot be avoided by substituting valves of a larger size, which, instead of giving increased freedom to the discharge of the steam, are actually inferior in this respect to the smaller valve.

This arises from the circumstance that the pressure required to hold down the valve increases as its area or as the square of its diameter; whilst its area for discharge increases only as its circumference or directly as its diameter.

This result is also not altered in the cases where, instead of using a lever with a spring balance at the end, a large spiral spring is employed, pressing directly upon the valve; the pressure of the spring and its motion being then the same as those of the valve, instead of the pressure of the spring being diminished and its motion increased, both in the same ratio, by the action of the lever.

Prior to the time of the grant of Richardson's letters patent referred to, it appears to have been the particular aim of all inventors in this direction to construct a valve that would open sufficiently wide to carry off the steam faster than it was generated above the pressure the boiler was intended to be subjected to.

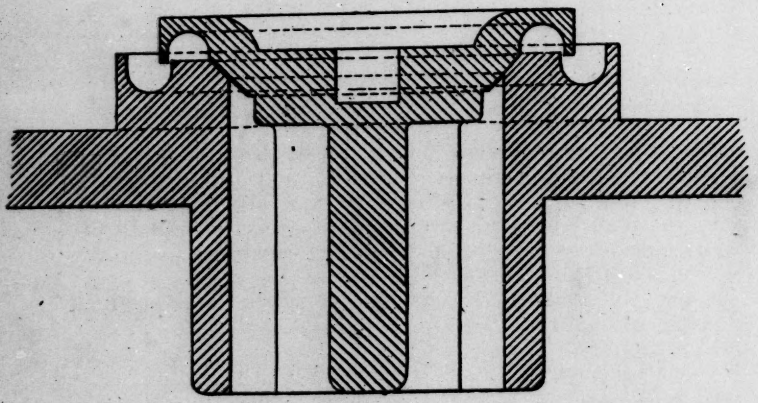
The construction adopted to carry out this object was to provide an annular flange upon or near the periphery of the valve and beyond its seat or ground joint, so constructed in relation to the valve-seat casing as to form a chamber beneath it, and having a contracted outlet from said chamber to the atmosphere that would arrest the current of the escaping steam, which, by its expansion or recoil action, would produce a pressure within said chamber to act
59 upon the under side of the additional flange and give greater lift to the valve.

This construction perfectly served its purpose; that is, to overcome the increasing resistance of the spring and permit the valve to open sufficiently wide to carry off the steam much faster than it was generated, and so prevent a boiler from being subjected to a higher pressure than that to which the valve was adjusted.

All valves operating upon this principle which existed prior to the grant of Richardson's letters patent were provided with additional surface, so arranged as to accomplish this result.

It served the sole purpose of securing a higher lift to the valve, and overcame the danger of over pressure.

In practical use, however, a new and worse difficulty arose from such construction. It was found that after the valve had opened wider it would not return to its seat until the working pressure in the boiler had been lost—twenty per cent., and in some instances



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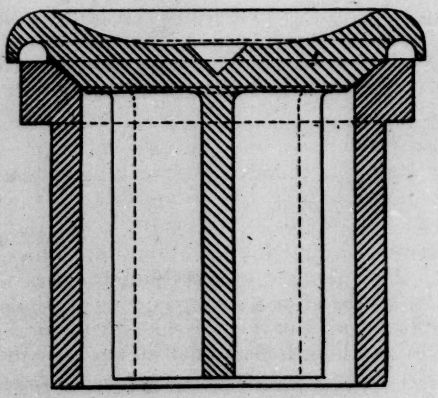
RICHARDSON VALVE

U. S. Letters Patent, No. 58,294, September 25th, 1866.



nearly fifty per cent., of the pressure being wasted. This practically deprived it of utility, and such a valve never went into use.

Mr. Richardson's invention overcame this last-mentioned defect; and it consisted essentially in proportioning said chamber, its horizontal area, and its escape opening to each other and to the degree of tension of the spring, whereby such a valve will suddenly close when the pressure in the boiler is reduced but slightly below the pressure at which the valve opened.

Mr. Richardson's first patent of 1866 describes, for the first time in the art, a safety valve which not only has the capicity for opening wider and relieving the boiler at the time when the pressure has risen above the working pressure, but which will also close promptly when the pressure has been reduced either to the working pressure of the boiler or to a point slightly below it; the valve operating to open or close within a very short range of pressure—usually in practice three or four pounds—and possessing capabilities of working within one pound.

In this patent Richardson refers to this peculiar and original quality of his valve in these words:

(Here follows diagram, marked page 60.)

61 & 62 "With my improved safety valve, constructed as now described, and attached to the generator in the usual way, the steam, escaping in the direction indicated by the arrows in figure 3, first lifts the valve from its seat and ground joint E F, and then passing into the annular chamber D D, acts against the increased surface of the valve-head, and by this means, together with its reaction produced by being thrown downwards upon the valve-seat E E, it overcomes the rapidly increasing resistance of the spring or balance, lifts the valve still higher, and escapes freely into the open air until the pressure in the generator is reduced to the degree desired, when the valve will be immediately closed by the tension of the spring or balance."

Thus not only does Richardson say that his valve possesses the function of working in close relation to the working pressure of the boiler, which is the degree desired, but *h* describes, very accurately, the means for effecting this result, as follows:

"This flange or lip *c c*, fitting thus loosely around the valve-seat *e e*, is separated from it by about one sixty-fourth of an inch of an ordinary spring or balance. For a strong spring or balance this space should be diminished, and for a weak spring or balance it should be increased to regulate the escape of steam as required."

He gives exact and definite proportions for the size of his stricture* in connection with an ordinary spring; and he also gives the proportion in which the area of the safety valve, constantly exposed to steamway when closed, is to be increased, and a proper chamber

*The escape passage from the supplemental chamber to the atmosphere; this being, since the introduction of the Richardson valve, technically known in the art as a "stricture."

formed under it, in order to present sufficient additional area and space for the action of the escaping steam after the valve has lifted from its seat. He says:

"To the head of the common safety valve, indicated by all that portion of figure 2 lying within the second circle from the common centre, I add what is indicated by all that portion lying outside of the said circle, in about the proportion shown in the figure."

He follows this by directions which secure a chamber terminated by a stricture under this added area.

63 With these directions thus given in Richardson's patent, a definite rule was established in this field of invention; and thus, for the first time in its history, was the result produced of closing a valve with a very small margin of loss of pressure below the opening pressure, whereby nothing but excessive pressure was released, the working pressure remaining practically undisturbed.

Richardson was not the first to discover that by exposing an additional surface in the valve to the escaping steam the valve could be opened wider and the boiler relieved more rapidly, for the state of the art shows that that thing was well known long before the time of Richardson; but what he did discover was a practical way of doing that thing so that a valve which accomplished this result could be used by users of steam without undue waste occasioned by the gradual and sluggish seating of the valve, whereby not only the excessive pressure was released, but a very large part of the pressure below the working pressure was absolutely lost.

This closing action in the Richardson valve from its extreme open position while discharging is as follows: When the excessive pressure is released the valve gradually recedes from its extreme open position, which reduces the size of the outlet at its seat, or ground joint. Now, if the stricture was correspondingly reduced in size, the pressure in the supplemental chamber would fall in the same ratio as the boiler pressure, and the valve would continue to close gradually so long as the sum of the boiler pressure and the supplemental pressure was reduced equally with the resilient power of the spring, and until the valve was seated; but when a certain point in the closing movement of the valve is reached the size of the outlet at the ground joint continues to diminish, while the size of the stricture remains constant, or does not diminish in so great a degree, consequently the pressure in the supplemental chamber falls at a much greater ratio than the boiler pressure, and the relief in the supplemental chamber is so rapid that the preponderance of the spring suddenly closes the valve; therefore, with a strength of spring that will allow the valve to open wide, and a size of stricture that will produce such an additional pressure in the supplemental chamber as to cause the valve to open wide, and also to permit it

64 to close near the pressure at which the valve opened, it is obvious that by substituting a weaker spring the size of the stricture should be increased to secure the same result; because the weaker spring does not require so much additional pressure in the supplemental chamber to compress it to a degree that will give an

equal lift to the valve; and in the closing movement of the valve the enlarged stricture will also give the early relief essential to the less powerful spring.

In this first patent of Richardson's a stricture, when once formed, was permanent, and could only be changed by an alteration, requiring a mechanic and tools to effect it. It could, for instance, be made smaller in size by burnishing in the edge of the depending flange. It could be made larger by turning off a part of the flange or of the extended valve-seat casing.

In 1869 Richardson patented a further improvement in this valve, in which the outlet for the escaping steam into the atmosphere could be increased or diminished in size at the will of the user without the assistance of a mechanic, and without removing the valve from the position where it was placed to work. This improvement consisted in providing a screw-ring adjacent to the escape opening, which, in its adjustment, would control the stricture, more or less, as desired. This feature of adjusting the stricture is referred to in Richardson's patent of 1869 in these words:

"One part of my present invention relates to a means for regulating or adjusting the area of the aperture for the escape of the steam after acting on the said surface outside of the valve seat, so that the valve may be set to close at any desired pressure below the pressure which will open it; and this part of my invention consists in making the aperture or apertures for the escape of the steam after it has acted on the said surface outside of the valve seat adjustable. * * The difference between the pressure against which the valve will close and the pressure by which it will be opened will depend upon the distance between the outer periphery of the flange *n* of the cap plate and the inner periphery of the projecting rim *q*. To render this adjustable, the area of the aperture for the escape of the steam beyond the valve seat must be adjustable. This is effected by the raising or lowering of the ring *u*. If it be set to its lowest position, the steam escaping from the valve will be free to escape between the top of the valve and the cap through the central aperture, and thence between the upper edge of the ring *u* and the disc *f*, without materially aiding to lift or hold up the valve; but by setting the ring *u* near to the under surface of the disc *f*, and thereby reducing the space for the escape of the steam, it will be caused to act, by its elastic force, against the annular space *o* of the cap plate, and thus assist in lifting the valve and holding it up."

He claims:

"The combination of the surface beyond the seat of the safety valve, with the means herein described for regulating or adjusting the area of the passage for the escape of steam, substantially and for the purposes described."

This improvement for adjusting the size of the stricture was novel with Mr. Richardson.

So that he not only made the discovery that the size of the stricture was the controlling element in the organization of an automatic safety valve, and was the inventor of the first practical valve that

applied this discovery in the arts, but he was also the inventor of the first and best mechanism, forming an organic part of the valve, which enabled the stricture to be adjusted by the user.

The state of the art as it existed at the time of Richardson's invention discloses that English letters patent were granted to—

Name.	Residence.	Date.	Number.
Charles Ritchie	Aberdeen, Scotland	August 3, A. D. 1848	12,078
James Webster	Birmingham, England	July 12, " 1857	1,955
William Hartley	Bury, "	August 19, " 1857	2,205
Thomas Green, Jr.	London, "	May 9, " 1859	1,165
Charles Beyer	Manchester, "	April 20, " 1863	1,038
William Naylor	Dalston, "	July 21, " 1863	1,830

And United States letters patent to—

Henry Waterman	Hudson, N. Y.	November 15, A. D. 1853	10,243

(Here follows diagram, marked page 66.)

67 & 68 for safety valves of the class to which the inventions of Richardson appertain.

I have carefully examined, and I understand the construction and operation of the contrivances respectively described and shown in these several letters patent; and I have experimented with safety valves made in accordance with those letters patent, and I can explain their construction and operation.

Not one of these prior patents referred to prescribed a practical rule of action to be followed in the construction of the valve shown; and not one of them, when constructed as shown and described, can be made to operate in their closing action similar to the Richardson valve, nor without a loss of pressure of at least twenty per cent., and in some instances nearly fifty per cent.

The Ritchie valve,

shown in Plate 2, is what is known in the arts as a "piston" valve, and was devised for use as a supplemental relief valve.

This valve, when constructed in accordance with the patent, will cause, when opened, a reduction of the boiler pressure of about fifty per cent. before it will seat itself.

It contains no stricture whatever; but the supplemental flange fits closely to the surrounding wall, and it is incapable of operating in the manner discovered by Richardson.

It is the only valve among those shown in these anterior patents that can possibly be converted into a Richardson valve by changing its relation of parts; for example, a stricture might readily be made by simply turning off the periphery of the supplemental flange a definite amount, as shown, for example, in Plate 3, and it can then be operated similar to a Richardson valve.

This would appear to be a very simple matter in effecting its conversion, since Richardson has told us in his patent how to do it; but Mr. Ritchie failed to discover it—this fact being a striking illustration, showing how near an inventor may approach perfection, and yet fail to provide the connecting link thereto.

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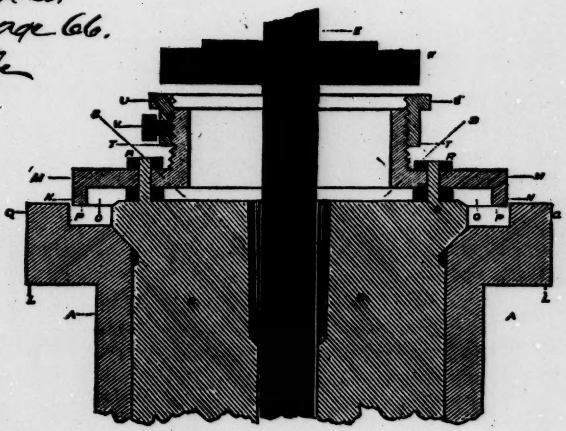


RICHARDSON VALVE. Letters Patent of the United States, No. 85,963, Jan. 19, 1869.

His plan of varying the amount of reduction of pressure, so
69 far as it extended, was based upon an entirely different theory, viz., that of comparative areas.

In a letter to the "Artisan," in further explanation of his valve, published in vol. 16, page 173, he states:

"That the top area being made double that of the under side or steamway, such a valve would quickly reduce the pressure in the boiler to half that at which the valve lifted; and so also of other proportions."

That is, if the top area is made double that of the steamway, the value will reduce the pressure in the boiler one-half. This was true. Then, by other "proportions," if the areas are in proportion of one and one-half to one, his theory was the pressure would be reduced but one-third; and if the respective areas were but one and one-third to one, his theory was the pressure would be reduced but one-fourth.

To this extent the top or supplemental area is so far reduced that the valve will not lift sufficiently against the tension of the spring to permit the supplemental flange to rise above the recess in which it moves, and, therefore, Ritchie's theory about comparative areas as a rule was not true, because the valve becomes inoperative before the practical limited amount in the reduction of pressure could be obtained.

And further, in relation to this valve, it is objectionable to have anything like a piston valve, on account of the liability of deposits collecting upon the rubbing surface sufficient to impede the proper action of the valve.

An essential point to be aimed at in any construction of safety valves is to ensure certainty of action, as well as freedom from liability to derangement.

The Waterman valve,

shown in Plate 4, was designed to open wider than the ordinary valve, and was provided with an annular flange to present additional surface to the escaping steam to attain such object similar to the Ritchie valve; but no stricture was provided so as to produce additional pressure beneath the flange.

70 The valve was loaded with a weight, and no increased resistance was offered to the extra lift sought, The main difficulty to be overcome with such valve in its increased range of action was to compensate for the extreme vibrations of the end of the lever to which the weight was suspended, a rod being applied to the end of said lever carrying a piston that was fitted within a cylinder containing oil or other liquid to cover the piston, and whereby in the movement of the piston the sudden vibrations of the valve lever were checked.

The valve, when constructed in accordance with the patent, would not close until the pressure in the boiler had been reduced to a degree proportionate to the additional resisting surface contained in the supplemental flange, amounting to twenty per cent. of the boiler pressure.

The Green valve,

shown in Plate 5, is provided with a supplemental surface beyond the ground joint and above the same, in the form of a separate disc, or flange, connected to the valve. A fixed casing is also provided, that surrounds the top of the valve and flange, which forms an intermediate chamber between the flange and the valve, with a constricted passage to the atmosphere.

This valve is loaded with a weight, and, therefore, there is no increased resistance to overcome in its lifting action; but a portion of the steam that enters the chamber is available to assist in raising the valve higher after it has lifted from its seat; that portion of the surface of the flange directly over the valve being ineffective for such purpose.

To obtain the necessary amount of lift with this construction, the patentee increased the diameter of the flange to an extent that would present a supplemental surface to the steam and compensate for that part of said surface directly over the valve that is ineffective. In doing this he made a chamber of such capacity that the quantity of steam necessary to fill it, and create an additional pressure to lift the valve higher, cannot be got rid of in the return or closing movement of the valve; and this obstructs said closing action to such a degree that nearly fifty per cent. of the working pressure in the boiler escapes before the valve will return to its seat.

71 The Webster valve

embraces all that is shown in the "Green" valve, and differs from it only in making the supplemental flange vertically adjustable upon the valve spindle, by means of which the amount of reduction of boiler pressure may be varied within certain limits.

In my experiments with this valve, made in accordance with the Webster patent, I found that it could not be adjusted to operate within the limits desired in practice, nor to operate with a measured degree of reduction of pressure.

With the valve set to open at one hundred pounds per square inch pressure in the boiler, and the flange adjusted upon the valve spindle to leave a space of one-eighteenth ($\frac{1}{18}$) of an inch between it and the top-wall on the casing, as shown in figure 1 of the patent drawing—the valve partially closed when the pressure in the boiler was reduced to eighty-five pounds per square inch, showing a reduction of fifteen pounds per square inch, and at no other position of the valve could this margin of reduction be obtained; slight variations in the adjustment of the flange, up or down, producing widely different and disproportionate results.

The relative proportion of its parts essential to regulate its action to the requirements demanded, and found in the Richardson valve, is widely different; and the best that can be said for it is, it contains an aggregation of parts, assembled without regard to any rule of action, and in ignorance of the abundant conditions of the problem to be solved.

The Hartley valve.

This valve is also provided with a supplemental flange, but no stricture; the outlet from beneath said flange being so large as to permit a free escape, and, therefore, no accumulative pressure can exist beneath said flange.

This valve receives additional lift, due solely to whatever force may exist in the impinging action of the escaping steam beneath the supplemental flange.

The valve is loaded with a weight, which is constant; and there is no increased resistance to overcome in its opening movement.

72 Its operation in opening and closing is precisely like the ordinary valve; and while it will lift higher in its opening movement than the ordinary valve, its closing action is extremely slow, and it will not seat itself until about thirty per cent. of the working pressure in the boiler has escaped.

The Beyer valve.

This valve is also provided with an overchanging flange, but has no stricture.

The area of the outlet from beneath the flange increases in diameter and corresponding size beyond any intermediate point of the passage from the steam space in the boiler, and, therefore, the escaping steam is not checked in its escape, nor a consequent pressure obtained beneath the flange. Like the Hartley valve, the only force that tends to cause an additional lift to the valve is the impinging action of the escaping steam upon the under surface of the flange, which is not appreciable in overcoming the increased resistance of the spring, and effecting a greater lift to the valve.

This valve is far inferior, in its closing action, to the common safety valve, and possesses no advantage over it in relieving the excessive pressure in the boiler.

The Naylor valve

is also provided with a supplemental flange, and an annular space beneath said flange, which serves only as a conduit for the escaping steam; the supplemental flange merely directing the steam through said conduit.

There is no stricture to this conduit, and the escaping steam is not checked in its passage through it; and no additional pressure is produced within said annular space, and beneath the supplemental flange.

To obtain the desired additional lift to the valve, so as to provide for any increase of the pressure in the boiler beyond the intended limit of pressure, Naylor designed a contrivance that caused the spring that passes upon the valve to act, not through a constant lever, but through one which varies in its effective length;

73 diminishing in length, as the valve rises, in the same proportion that the tension of the spring is increased by the rising of the valve, so as to prevent any increase taking place in the total pressure upon the valve.

None of these prior valves had the capacity of closing, when the working pressure was slightly reduced; that is, neither of these valves had the capacity for so handling the steam in a boiler as to keep the supply of steam for doing the work practically complete and efficient all the time without submitting the boiler to any greater strain than was absolutely necessary for the pressure to do the work.

The proportioning of the supplemental chamber and its stricture to the spring, and regulating the action of the spring by the size of the stricture, so far as I am able to discover, was original with Richardson; and it is upon this discovery that the action of these spring-loaded safety valves depends.

In my experiments with this Richardson valve, and others of later date, that have been made to produce similar results—that is, to open sufficiently wide to relieve the boiler, and promptly close when the pressure in the boiler had been slightly reduced—the relative conditions regulating the action of such valves is the same in every one of them.

With a valve constructed as Richardson describes in his patent, and in proportions there specifically stated, and with an ordinary spring, for instance, one that would sustain a compression of about one-fourth of an inch to resist a boiler pressure of one hundred pounds to the square inch, the valve will open promptly and sufficiently to relieve the boiler, and suddenly close when the pressure is slightly reduced from that at which it opened.

To show the absolute necessity of maintaining the relative conditions of amount of supplemental surface, strength of spring, and size of the stricture which controls the pressure within the chamber, I substituted a weaker spring, one that would sustain a compression of one half-inch, under a boiler pressure of one hundred pounds to the square inch as before; the result was that the valve lifted higher, and, consequently, discharged a greater quantity of steam into the chamber.

Now, if the stricture had not been changed, the valve would

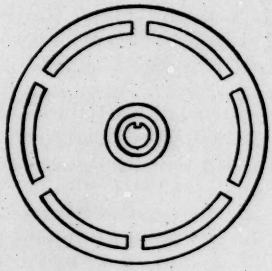
(Here follows diagram marked page 73½.)

74 not seat as quickly as in the former instance, for the reason that the stricture was too small to relieve the chamber of this extra quantity of steam; and, consequently, the boiler pressure was reduced to a greater extent, before the valve seated itself; therefore, to maintain the same amount of reduction of pressure in a boiler with the weaker spring, the size of the stricture must be enlarged precisely as Richardson states in his patent, and, *vice versa*, when a stronger spring is used, the stricture must be diminished to maintain the same amount of reduction, as he also sets forth.

I have examined two safety-valves, submitted to me by the complainants in this case, bearing the following marks stamped upon them:

"E. B. Kunkle, pat'ee and manuf'r, Fort Wayne, Ind.; pat. May 4th, '75, and July 24th, '77;" shown in Complainants' Exhibit Drawing, Kunkle, A; and "E. B. Kunkle, pat'ee and manuf'r, Fort Wayne, Ind.; pat. May 4th, '75, July 24th, '77," and shown in Complainants' Exhibit Drawing, Kunkle, B.

Coniplainants Exhibit Drawing Kunkle A.
(Without Adjustable Screw Ring.)



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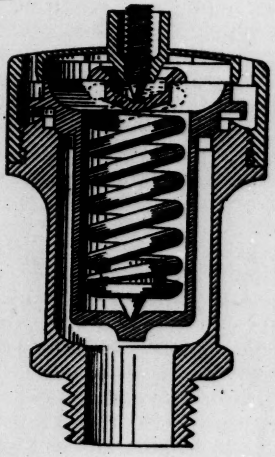


I have tested the said valves, and I understand the construction and operation of the same.

I have also examined two patents granted respectively May 4th, 1875, and July 24th, 1877, to Erastus B. Kunkle, of Fort Wayne, Ind., and I understand the contrivances therein described, and the same are embodied in the valves complained of.

The "Kunkle" valve, represented in Exhibit drawing, Kunkle, A contains an annular flange upon the periphery of the valve, which presents additional surface for the escaping steam to act upon; said flange being constructed and arranged in respect to the extended valve-seat casing to form a chamber with a permanent constructed escape passage.

The relative proportions of the additional surface, capacity of the supplemental chamber, strength of spring, and size of the stricture are, relatively, the same as set forth in Richardson's first patent of 1866.

I caused experiments to be made with this valve on the 10th of November, 1880, and found its operation to be identical with a Richardson valve made in accordance with said patent.

75 The Kunkle valve represented in Exhibit Drawing, Kunkle, B, includes the same construction and relative proportion of the parts enumerated in reference to Exhibit Drawing, Kunkle, A, and set forth in Richardson's patent of 1866.

This valve is further provided with an adjustable screw ring for varying the size of stricture, identical with the device set forth in the Richardson patent of 1869, and for the same purpose.

I have caused extended experiments to be made with this valve, together with a Richardson valve which included both of Richardson's inventions, and made in accordance with Richardson's patents; these valves being of corresponding commercial size, and known to the "trade" as two and one-quarter inch valves. The experiments were conducted at the same time and place, under precisely the same conditions; and the comparative results obtained were the same, and the action of the valves identical.

The following table, giving the dimensions in these valves of the corresponding parts involving the essential proportions; the relative compression of the spring; the additional pressure within the supplemental chamber; together with the comparative results noted in a subsequent table, conclusively shows that the inventions of Richardson are directly appropriated in the "Kunkle" valve.

	Richardson.	Kunkle.
1. Diameter of steam-way	2.26″	2.25″
2. Area or initial surface exposed to the steam-way	4.201″	3.97″
3. Total area of valve and extended flange	8.45″	7.94″
4. Supplemental area [difference of above areas]	4.438″	3.97″
5. Circumference of extended flange	10.147″	9.99″
6. Compression of spring under 100 lbs. per square inch	.5″	.4″

The Kunkle valve, Exhibit B, contains the adjustable screw ring for varying the size of the outlet from the supplemental chamber beneath the extended flange on the valve, and is provided with notches upon its periphery, which engage with a spring stop
76 on the valve-casing to facilitate the uniform and delicate adjustment necessary, the same as adopted in the Richardson device.

(Here follows diagram, marked page 75½.)

In order that the terms employed in the following description and table, with reference to the amount of adjustment of the screw ring which regulated the size of the stricture, may be understood, I will state, that, for convenience and certainty, a series of external slots, or notches, are provided in said ring, extending entirely around the same, and designed to receive a pin, or spring stop, which also enters into a corresponding hole in the valve-casing, which retains the ring at whatever position it is placed; a rotation of the adjustable ring, one notch being equivalent to a vertical movement of the same, one three hundred and twenty-fourth of an inch in the Richardson device, and one five hundred and ninety-fourth of an inch in the Kunkle device. The same number of screw threads per inch, namely, eighteen, is also adopted, to give the same amount of vertical movement with each complete rotation of the ring. The valves were both adjusted to open at one hundred pounds' pressure per square inch, and the size of the stricture was taken when the adjustable screw ring was set to produce the desired and same amount of reduction of pressure in the closing operation of the valves.

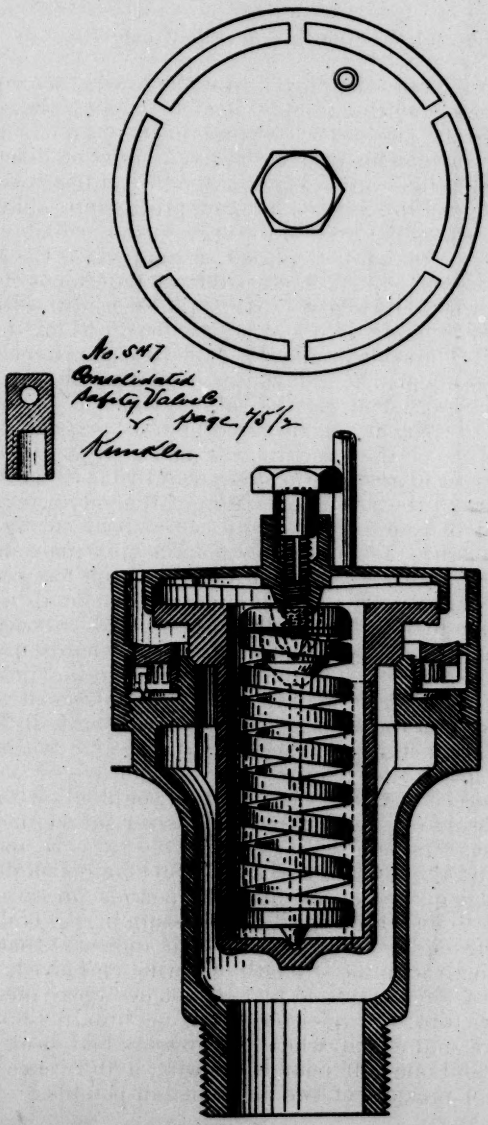
The amount of compression of the commercial spring necessary to sustain a pressure of one hundred pounds per square inch is five-tenths of an inch in the Richardson valve, and but four-tenths of an inch in the Kunkle valve; this difference of one-tenth of an inch being partly due to the difference in the areas of the respective valves exposed to the steam way when seated, the Richardson valve presenting greater surface thereto, and requiring the proportionate greater power of spring to maintain the valve in its seat. The comparative strength of the spring, therefore, is substantially alike.

My first experiments with the Richardson valve was made with a strength of spring that required a pressure of five-sixteenths of an inch to produce a degree of tension that would allow the valve to open at a pressure of one hundred pounds per square inch.

The ring was first adjusted to entirely close the escape opening, or stricture, and then turned two notches to obtain a slight opening, the valve opened at one hundred pounds' pressure, and con-
77 tinued to discharge until the pressure in the boiler was reduced to eighty-six pounds—which indicated that the stricture was too small with the strength of spring employed.

The ring was then adjusted to four notches open, increasing the size of the stricture; the valve opened at one hundred pounds' pressure, as before, and closed when the pressure had been reduced to eighty-eight and one-half pounds, showing a difference in amount of reduction of pressure of two and one-half pounds.

Complainants Exhibit Drawing Knuckle B.
(Showing Adjustable Screw Ring.)



The next and succeeding experiments, up to the tenth trial, the ring was adjusted to gradually increase the size of the stricture,—the amount of reduction of pressure at the time the valve seated being as gradually diminished until it closed at ninety-seven pounds, which was the degree of reduction desired—the ring at the last or tenth trial being adjusted to sixteen notches open.

I then substituted a weaker spring, in which the amount of compression required to control the valve to open at one hundred pounds' pressure per square inch was five-tenths of an inch, or three-sixteenths of an inch more than that required in the spring employed in the above experiments; the adjustable ring remained at the same position, namely, sixteen notches open; the valve opened at one hundrep pounds, and closed when the pressure had fallen to ninety-one pounds, showing a difference in the amount of reduction of six pounds with the weaker spring and corresponding-sized stricture.

The size of the stricture was still further increased until the ring was adjusted to twenty-seven notches open, when the valve opened at one hundred pounds' pressure, and closed at ninety-seven pounds, which was the same result as that obtained in the last trial with the stronger spring, but with the size of the stricture greatly increased.

The gradual and uniform amount of reduction of pressure obtained by the delicate and regular adjustment of the size of the stricture shows, conslusively, the necessity of definite proportions of the parts, and a knowledge of the effects to regulate the action of the valve.

My next experiment was made with the Kunkle valve, Exhibit B, with a strength of spring that required a compression of
78 five thirty-seconds of an inch to produce a degree of tension that would allow the valve to open at a pressure of one hundred pounds per square inch.

In the first trial I adjusted the screw ring three notches from its position to close the stricture; the valve opened at one hundred pounds, and closed at ninety-one pounds.

Second trial. Ring adjusted to four notches open; valve opened at one hundred pounds, and closed at ninety-three pounds.

Third trial. Ring adjusted to five notches open; valve opened at one hundred pounds, and closed at ninety-three and five-tenths pounds.

Fourth trial. Ring adjusted to six notches open; valve opened at one hundred pounds, and closed at ninety-four pounds.

Fifth trial. Ring adjusted to seven notches open; valve opened at one hundred pounds, and closed at ninety-four and five-tenths pounds.

Sixth trial. Ring adjusted to eight notches open; valve opened at one hundred pounds, and closed at ninety-five pounds.

Seventh trial. Ring adjusted to nine notches open; valve opened at one hundred pounds, and closed at ninety-five and five-tenths pounds.

Eighth trial. Ring adjusted to ten notches open; valve opened at one hundred pounds, and closed at ninety-six pounds.

Ninth trial. Ring adjusted to eleven notches open; valve opened at one hundred pounds, and closed at ninety-seven pounds.

I then substituted a weaker spring, that sustained a compression of four-tenths of an inch, to permit the valve to open at one hundred pounds per square inch, as before; the adjustable screw ring remaining eleven notches open, as in the last trial with the stronger spring.

Tenth trial. Valve opened at one hundred pounds, and closed at ninety-three pounds.

Eleventh trial. Ring adjusted to thirteen notches open, still further increasing the size of the stricture; valve opened at one hundred pounds, and closed at ninety-four pounds.

Twelfth trial. Ring adjusted to fifteen notches open; valve
79 opened at one hundred pounds, and closed at ninety-four and five-tenths pounds.

Thirteenth trial. Ring adjusted to seventeen notches open; valve opened at one hundred pounds, and closed at ninety-five pounds.

Fourteenth trial. Ring adjusted to nineteen notches open; valve opened at one hundred pounds, and closed at ninety-six pounds.

Fifteenth trial. Ring adjusted to twenty notches open; valve opened at one hundred pounds, and close at ninety-six and five-tenths pounds.

Sixteenth trial. Ring adjusted to twenty-one notches open; valve opened at one hundred pounds, and closed at nine-seven pounds.

Showing the same result which had been obtained with the stronger spring, and with the adjustable screw ring at eleven notches open, by use of a weaker spring and larger stricture; and showing, conclusively, that the size of the stricture, with a weaker spring, must be increased in order to obtain similar results to those of the stronger spring, precisely as Mr. Richardson sets forth in his first patents of 1866.

This position of the ring produced the best action obtainable in this valve, with the spring used; and, therefore, I proceeded to note the pressure within the supplemental chamber, the size of the stricture when the valve was opened wide, and the amount of lift.

The pressure in the supplemental chamber, with the valve opened wide, and the pressure in the boiler maintained at one hundred pounds per square inch, was forty-two pounds per square inch, as indicated by a standard pressure gauge connected therewith.

This multiplied by the additional surface gave a total pressure in the chamber of one hundred and sixty-seven pounds.

The area of the stricture at the extreme open position of the valve was one and ninety-five one-hundredths inches, and the amount of lift of the valve sixteen one-hundredths of an inch, the lift being determined by considering the measured compression of the spring that resists the boiler pressure when the valve is seated, and computing the proportionate further compression of the spring
80 produced by the additional pressure upon the extended surface when the valve is lifted, the difference in the amount of compression indicating the lift.

The relation of the supplemental surface, the pressure exerted

within the supplemental chamber, and upon said surface, the size of the stricture that controls said pressure, and the effect produced ubon the closing action of the valve, when springs of different strength are used, by varying the size of said stricture,—which regulates its action—are alike in both the Richardson & Kunkle valves.

From my experiments with the Richardson valve, I find that the total pressure within the chamber, and beneath the supplemental surface, when the valve was opened wide, was about sixty-six lbs.; the area of opening of the stricture in this position of the valve was seventy-seven one-hundredths of an inch. Corresponding total pressure in the supplemental chamber of the "Kunkle" valve was one hundred and sixty-seven lbs.; and the area of the stricture, with the valve opened wide, was one and ninety-five one-hundredths of an inch.

Therefore, with their respective valves opened wide and discharging steam under one hundred pounds' pressure to the square inch, and closing in the same manner, with the same amount of reduction of pressure, a comparison of the same, with respect to the conditions given above, may be stated as follows:

The total pressure [66 lbs.], in the supplemental chamber of the "Richardson" valve is to the corresponding total pressure [167 lbs.] in the supplemental chamber of the "Kunkle" valve, as the area of the stricture in the "Richardson" valve [.77 inches] is to the area of the stricture in the "Kunkle" valve, [1.95 inches]; or it may be stated briefly.

K. P. (167): R. P. (66):: (K. S. 1.95″): R. S. (.77″).

Therefore, in both the Richardson and Kunkle valves, with springs of different strength, an adjustment of the size of the stricture leading from the supplemental surface within the supplemental chamber regulates the action of the valves in closing under
81 more or less reduction of boiler pressure, in the same uniform and positive manner.

Table Showing Result of Trials.

Richardson Valve.

Strong spring, comp $\frac{5}{16}$ of an inch.

1	Ring.	2	Notches	open.	Valve opened at	100 lbs.	Closed at	86 lbs.
2	"	4	"	"	100	"	" 88.5	"
3	"	6	"	"	100	"	" 90	"
4	"	8	"	"	100	"	" 92	"
5	"	10	"	"	100	"	" 94	"
6	"	12	"	"	100	"	" 95	"
7	"	14	"	"	100	"	" 96	"
8	"	15	"	"	100	"	" 96.5	"
9	"	16	"	"	100	"	" 97	"

Substituted weaker spring, comp. .5 of an inch.

(Commercial Spring.)

10	Ring.	16	Notches	open.	Valve	opened at	100 lbs.	Closed at	91 lbs.
11	"	18	"	"		100 "	"	92	"
12	"	20	"	"		100 "	"	94	"
13	"	22	"	"		100 "	"	95.5	"
14	"	24	"	"		100 "	"	96	"
15	"	26	"	"		100 "	"	96.5	"
16	"	27	"	"		100 "	"	97	"

Pressure in the supplemental chamber at the 16th trial, 15 lbs. per sq. inch. Total pressure, 66 lbs.

Kunkle Valve.

Strong spring, comp. $\frac{5}{32}$ of an inch.

1	Ring.	3	Notches	open.	Valve	opened at	100 lbs.	Closed at	91 lbs.
2	"	4	"	"		100 "	"	93	"
3	"	5	"	"		100 "	"	93.5	"
4	"	6	"	"		100 "	"	94	"
5	"	7	"	"		100 "	"	94.5	"
6	"	8	"	"		100 "	"	95	"
7	"	9	"	"		100 "	"	95.5	"
8	"	10	"	"		100 "	"	96	"
9	"	11	"	"		100 "	"	97	"

82 Substituted weaker spring, comp. .4 of an inch.

(One contained in the valve purchased.)

10	Ring.	11	Notches	open.	Valve	opened at	100 lbs.	Closed at	93 lbs.
11	"	13	"	"		100 "	"	94	"
12	"	15	"	"		100 "	"	94.5	"
13	"	17	"	"		100 "	"	95	"
14	"	19	"	"		100 "	"	96	"
15	"	20	"	"		100 "	"	96.5	"
16	"	21	"	"		100 "	"	97	"

Pressure in the supplemental chamber at the 16th trial, 42 lbs. per square inch. Total pressure, 167 lbs.

As before stated, not one of the prior patents referred to prescribed any practical rule of action to be followed in the construction of the valves shown; and not one of them, when constructed as shown and described, could be made to operate without a loss of at least twenty per cent. of the working pressure of the boiler, nor with any degree of reduction that could be measured by any adjustment of the parts.

The letters patent referred to, granted to Kunkle for his valves, show and describe all the particular and essential features necessary to their operations, precisely as set forth in Richardson's patents. The respective claims, however, contained in these patents, refer to

minor details of construction only, that are pure additions to Richardson's inventions; and these patents specify as Kunkle's invention only the mechanical details and combinations which relate to such additions.

In the original application of Kunkle for a patent, a claim referring to the main construction of the valve that is in controversy in this suit, was introduced as original claim 3.

The action of the Patent Office on this claim confirms my views. It was rejected on reference to Richardson's patent, as seen in the accompanying copy of file wrappers, etc.

Summary.

As a summary of the history of this class of safety valves, it may be said that Ritchie contrived, in 1848, a valve with an ex-
83 tended surface, and a steam-chamber beneath the extended surface, and that he proposed to regulate the amount of reduction of pressure in the boiler by changing the ratio of the area of extended surface to that of the steam-way.

This contrivance, as he presented it in the drawing and specification of his patent, had no stricture, and would reduce the pressure in the boiler fifty per cent. Any attempt to change the area, so as to get a moderate reduction of pressure, would have been, with the valve as shown by him, impracticable; and any attempt to regulate the reduction of pressure, by a change of the area of the extended surface, it will be seen would have been very troublesome, if not absolutely impossible, in practice.

In a Ritchie valve, made as he described, with the extended surface-flange fitting closely the walls of the valve casing, it would be impossible, or exceedingly difficult, to alter the proportion of the two areas; and, inasmuch as it is next to impossible to determine precisely, in advance, in the process of manufacture, or in the process of fitting, the tension of a spring necessary to hold a given amount of pressure and allow a proper lift to the valve, to fit such a valve as this for work, even with a reduction of fifty per cent. of pressure, would require frequent experimenting with springs, the tension of which would vary as the valve was exposed to high temperatures; so that the Ritchie valve did not contain in itself, and was not adapted by its construction to contain, any delicate degree of adjustability, but was a crude instrument, which presented only part of the contrivance shown by Richardson, and none of its nice features.

So far as anything can be discovered from Webster, as to his notions of adjustability, it seems as if he proposed to have constant relation of area of initial surface to area of extended surface in the proportion of about one to two and a half, which is very much larger than Ritchie's, and very much larger than has practically been found necessary. And then he proposed to get his adjustability by changing the quantity of steam in the supplemental chamber to be handled by the stricture, his stricture remaining practically constant.

This, it will be seen, was a clumsy and inefficient way of going at the work, and the Webster valve did not succeed in working

84 better than with a loss of twenty per cent. of its pressure, which is far greater than is allowable in practice.

These two valves are the only two, of which the inventors suggested that the reduction of pressure could be in any degree regulated.

It is obvious on examination of the things that contribute to the working of an automatic safety-valve, that one of them is the spring. Another is the ratio of the extended surface to the initial surface. A third is the size of the chamber under the supplemental area, and a fourth is the size of the stricture.

Of these four things the spring is an exceedingly difficult thing to regulate in itself, and also exceedingly difficult to make of any determinate nicety of tension. The ratio of one surface to another is also a thing that would be difficult to change in any given metallic valve. The size of the chamber again would be difficult to change, and even when altered, as in the Webster valve, does not give delicacy or precision of adjustment by its alteration.

The stricture, however, is formed between two adjacent metallic surfaces, either one of which could readily, if necessary, be burnished away, and so the stricture could be adjusted in a valve of the construction of Richardson's patent of 1866 much more easily, much more delicately, much more mechanically than by either of the other things.

In the arrangement for adjusting the stricture in the Richardson patent of 1869, by the movement of an adjustable screw ring to impede the passage of the steam to the open air, the means are simple, practical, and mechanical, and not liable to get out of order. Either of the other adjustments suggested are imperfect and unpractical. Very great comparative changes in them give very small results; while it is seen that the change of stricture to a very limited degree gives very considerable results. The stricture is, therefore, the micrometer measure of all this work of spring, extended surface, and expansion chamber, and it is placed at the very point where it is accessible without disturbing other things.

Richardson's discovery was, first, in 1866 that the stricture was capable of handling the other parts of the construction, and
85 of controlling their action, and he embodied that discovery in a practical working mechanism, and he further improved that mechanism in 1869 by the adaptation of a mechanical means by which the controlling action of a varied stricture upon the other parts of the valve could be readily called into action without the aid of a mechanic, or a mechanic's tools, by simply moving a screw-sleeve, which was a part of the organization of the valve.

He claimed in 1866 "A safety-valve with circular or annular flange or lip *c c* constructed in the manner, or substantially in the manner, shown, so as to operate as and for the purpose herein described."

He claimed in 1869 "The combination of the surface beyond the seat of the safety-valve, with the means herein described (the adjustable screw ring) for regulating or adjusting the area of the pas-

sage for the escape of steam, substantiatially as and for the purpose described."

Kunkle embodied in his valve all the parts, proportions, and arrangements of the Richardson organization, even to the screw sleeve of the patent of 1869, and his valve works exactly like Richardson's, and differs in its action and its mode of action from all the other valves which preceded it, exactly as Richardson's differs from those same valves.

CHARLES W. FORBES.

UNITED STATES OF AMERICA,
State & District of Massachusetts, Suffolk County, } ss:

BOSTON, *Jan'y* 10, 1881.

Personally appeared Charles W. Forbes, who, being duly sworn, on oath deposes and says he has read the foregoing affidavit, and subscribed the same, and the same is true, except the matters therein stated on information, and those he believes to be true.

Before me.

[SEAL.] F. F. RAYMOND, 2ND,
Notary Public.

86 A. D. 1848. No. 12078.

Locomotive and Other Engines.

Ritchie's Specification.

(Extract.)

To all to whom these presents shall come, I, Charles Ritchie, of Aberdeen, in the shire of Aberdeen and kingdom of Scotland, engineer, send greeting.

Whereas her present Most Excellent Majesty Queen Victoria, by her royal letters patent under the great seal of the united kingdom of Great Britain and Ireland, bearing date at Westminster the second day of March, one thousand eight hundred and forty eight, in the eleventh year of her reign, did, for herself, her heirs, and successors, give and grant unto me, the said Charles Ritchie, my executors, administrators, and assigns, her especial license, full power, sole privilege and authority, that I, the said Charles Ritchie, my executors, administrators, and assigns, or such others as I, the said Charles Ritchie, my executors, administrators, or assigns, should at any time agree with, and no others, from time to time, and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend within England, Wales, and the town of Berwick-upon-Tweed, my invention of "certain improvements in locomotive engines," in which said letters patent is contained a proviso that I, the said Charles Ritchie, should cause a particular description of the nature of my said invention, and the manner in which the same is to be performed, by an instrument in writing under my hand and seal, to be enrolled in her said Majesty's

high court of chancery within six calendar months next and immediately after the date of the said in part recited letters patent, as in and by the same, reference being thereunto had, will more fully and at large appear.

87 Now know ye, that in compliance with the said proviso, I, the said Charles Ritchie, do hereby declare that the nature of my said invention, and in what manner the same is to be performed, is fully set forth and ascertained in and by the present specification thereof, reference being had to the drawings hereto annexed and forming part hereof, by the letters and figures marked thereon, that is to say:

My invention consists in and has reference to certain improvements in locomotive and other engines carried into practical effect by the means or through the agency of certain new or improved mechanical combinations and arrangements, the said improvements having for their object the simplification of the construction, and the augmentation of the efficiency of such engines.

* * * * * * * *

The third part of my invention relates to an improved valve for regulating the admission of steam or other motive power to the working cylinders of locomotives and other engines; and further, to improvements in safety valves to be applied to the boilers of engines or other reservoirs of power.

* * * * * * * *

In order to explain my said invention as completely as possible, I will at once proceed to describe the mechanical combinations and arrangements of parts which I consider best calculated for carrying my said invention into practical effect. * * * S, S, mark spring safety valves, the construction of which will be better understood by referring to figure 7, where *d* marks the valve, and *e* the valve-seat, *f* the stem of the valve, passing through a guide-hole *g*. It will be seen, upon referring to this figure, that there are two forms of construction exhibited at that part marked A, showing a valve with a conical-shaped seat, marked B, being a flat valve, and I construct this valve with a flange *h*, which I call a compensation flange, such flange being let into the seat *e* vertically about one-sixth of the diameter of the steam-way in the valve seat. This valve is weighted by a helical spring *i*, shown at Figure 2, of sufficient power, according to the required pressure of the steam, and when it is intended to be used as a reserve safety-valve I place the spring around that part of

(Here follows 2 diagrams, marked pages 88–90.)

91 & 92 the stem below the valve; that is to say, within the boiler, as shown at Figure 2. The advantage of this form of construction of valve over the ordinary valve is as follows: As soon as the pressure of the steam raises the valve from its seat, the flange *h*, being exposed to the pressure of the steam, presents an increased surface, which compensates for the increasing resistance of the helical spring *i*, until the valve has been raised to a height equal to the area of the steam-way, when it allows the steam or vapor to escape freely.

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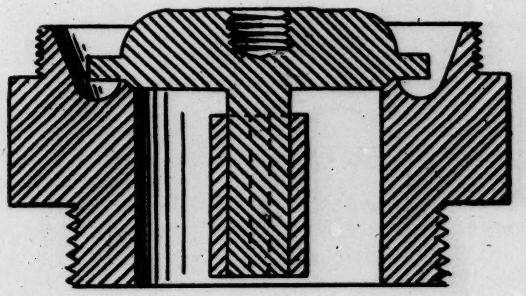
PLATE 3.



THE CONVERTED RITCHIE VALVE.

PLATE 2.

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Consolidated
Safety Valve Co.
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Kunkle

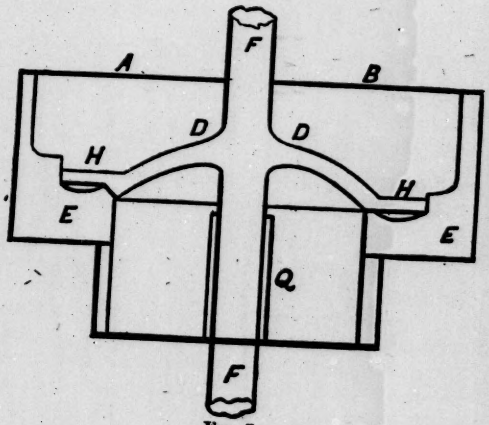

FIG. 7.

English Patent to CHARLES RITCHIE, No. 12,078, March 2, 1848.

When not intended as a reserve safety valve this valve may have the spring *i* placed above it. * * *

Having now described the nature of my said invention of certain improvements in locomotive and other engines, and in what manner the same is to be performed and carried into practical effect, I would remark that I do not claim the exclusive use of any of the separate parts above mentioned and referred to, when considered *per se* and apart from the purposes of my said invention as hereinbefore set forth and described; but what I claim as my said invention, whereof the exclusive use and advantage was granted to me by Her Majesty's letters patent as aforesaid, is as follows, *videlicit*:

Fourthly. I claim the construction of safety-valves with a flange, termed a compensation flange, without regard to manner in which such valves may be weighted, as hereinbefore particularly described and represented at Figure 7 of the drawings hereunto annexed.

In witness whereof I, the said Charles Ritchie, have hereunto set my hand and seal, this third day of August, in the year of our Lord one thousand eight hundred and forty-eight.

CHAS. (L. S.) RITCHIE.

93 A. D. 1857. No. 1955.

Safety Valves.

Letters patent to James Webster, of Birmingham, in the county of Warwick, engineer, for the invention of "an improvement or improvements in safety valves."

Sealed the 23d September, 1857, and dated the 14th July, 1857.

Provisional specification left by the said James Webster at the office of the Commissioners of Patents, with his petition, on the 14th July, 1857.

I, James Webster, of Birmingham, in the county of Warwick, engineer, do hereby declare the nature of the invention for "an improvement or improvements in safety valves," to be as follows:

In constructing safety-valves according to my invention, I place upon that part of the axis or stem of the valve which is prolonged above the top of the valve a sliding collar or flange, which is capable of being fixed in any desired position on the said stem or axis. When the said sliding valve or flange is adjusted in its lowest position its under surface constitutes, as it were, a horizontal shoulder upon the valve, the said shoulder extending from the top of the inverted cone forming the valve. When the conical valve is raised from its seat by the pressure of steam underneath, the steam, after escaping between the valve and valve-seat, acts upon the said shoulder and counteracts the increased resistance which is offered to the raised valve when the said valve is acted on by a spring. By adjusting the said sliding collar or flange to different heights on the valve-stem, the action of the steam upon it may be regulated.

I sometimes carry my invention into effect by making the
94 sliding collar in the form of a piston, fixed on the valve-stem

as a piston rod; I surround the said piston with a cylinder, in which the piston works loosely, and perforate the cylinder with holes, so as to allow the steam to escape when the piston has risen to the desired height. The action of this modification of my invention is essentially the same as that first described.

Specification in pursuance of the conditions of the letters patent, filed by the said James Webster in the Great Seal Patent Office, on the 12th January, 1858.

To all to whom these presents shall come, I, James Webster, of Birmingham, in the county of Warwick, Engineer, send greeting:

Whereas Her Most Excellent Majesty Queen Victoria, by her letters patent, bearing date the fourteenth day of July, in the year of our Lord one thousand eight hundred and fifty-seven, in the twenty-first year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said James Webster, her special license that I, the said James Webster, my executors, administrators, and assigns, or such others as I, the said James Webster, my executors, administrators and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for "an improvement or improvements in safety valves," upon the condition (amongst others) that I, the said James Webster, my executors or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent office within six calendar months next and immediately after the date of the said letters patent:

Now know ye, that I, the said James Webster, do hereby
95 declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof, that is to say:

My invention consists of the methods hereinafter described, and illustrated in the accompanying drawing of constructing safety valves.

Figure 1 of the accompanying drawing represents in vertical section a safety valve constructed according to my invention. *a* is the valve; *b*, the valve-seat; *c* is the stem or axis of the valve *a;* and *d*, the arm or lever by which the valve *a* is pressed to its seat *b* by a spring or weight on the prolonged end of the said arm or lever *d*. Upon the stem *c* of the valve I place a collar or flange *e* (shown separately in elevation in figure 2), the said collar or flange *e* is is capable of sliding on the valve-stem *c*, and is fixed at the desired height by the screw *f*. Around the valve-seat *b* I make a short case or hollow cylinder *g*, the sliding collar or flange *e* coming very nearly into contact with the top of the case or hollow cylinder

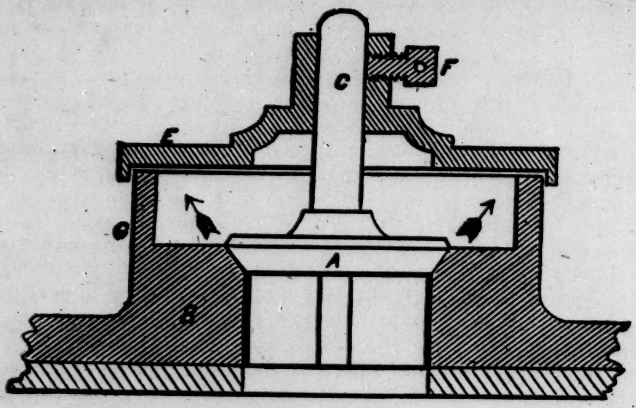

Fig. 1.

English Patent to James Webster, No. 1,955, July 14, 1857.

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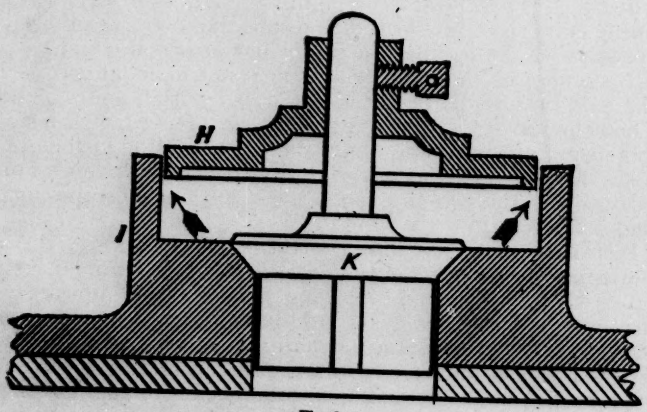

Fig. 2.

English Patent to James Webster, No. 1,955, July 14, 1857.

g when the valve *a* is upon its seat *b;* or the short case or hollow cylinder *g* may be dispensed with, and the sliding collar or flange *e* may be brought down on the stem *c*, so as to rest on the top of the valve *a;* I prefer, however, to use the case *g*, as represented. When the valve *a* is raised from its seat *b* by the pressure of steam, the said steam after escaping between the valve and valve-seat acts upon the collar or flange *e*, pressing the said collar or flange upwards, and thereby counteracting the increased resistance which is offered to the raised valve, especially when the said valve is pressed down by spring. By adjusting the sliding collar or flange *e* to different heights on the valve-stem *c*, the action of the steam upon it may be regulated.

I sometimes make the sliding collar or flange of less diameter than the case or hollow cylinder surrounding the valve. This modification of my invention is represented in figure 3 of the accompanying drawing, where *h* represents the sliding collar or flange, capable of being adjusted to any desired height above the valve *k* in the interior of the case or hollow cylinder *i*.

(Here follows diagram, marked page 96.)

Instead of fixing the sliding collar or flange rigidly upon the valve-stem, I sometimes attach it thereto by means of a helical or
97 & 98 coiled spring, as represented in vertical section in figure 4, in which said figure *l* is a coiled spring surrounding the valve-stem, and connected at its upper end with the nut *m*, and at its lower end with the sliding collar or flange *n;* the nut *m* is fixed in its place by a screw.

I sometimes carry my invention into effect in the manner represented in vertical section in figure 5; that is to say, I make the sliding collar *o* in the form of a piston, fixed on the valve-stem *p* as a piston rod; I surround the said collar or piston *o* and valve-seat *q* with a hollow cylinder *r*, in which the piston or collar *o* works loosely. The said hollow cylinder *r* is perforated with a series of holes, *s s*. When the valve *t* has been raised by the pressure of the steam, the said steam, acting on the under side of the sliding piston or flange *o*, raises the said piston or flange until it no longer covers, or only partially covers, the holes *s s*, when the steam freely escapes by the said holes *s s*.

Instead of placing a sliding collar upon the axis of the valve, I sometimes carry my invention into effect in the manner illustrated in figure 6; that is to say, I prolong the valve-seat upwards, so as to form a cylindrical casing around the valve marked *u*, the said casing being of little larger diameter than the valve *v*. When the valve *v* is closed, the steam acts only on the under surface of the valve, but as soon as the valve is raised the steam bears also against the conical sides of the valve, the area of which is thus virtually increased. This effect is produced by the casing *u*, and the action of the valve is analogous to that of the several valves hereinbefore described.

By constructing safety valves according to my invention, when

the steam acquires a sufficient pressure to raise the valve from its seat, the said valve is raised by the said steam higher than valves of the ordinary construction, and a free means of escape for the steam provided.

Having now described the nature of my invention, and the manner of carrying the same into effect, I wish it to be understood that I do not limit myself to the precise details herein described and represented, as the same may be varied without departing from the nature of my invention; but I claim as my invention the
99 methods of constructing safety valves, hereinbefore described, and illustrated in the accompanying drawing.

In witness whereof, I, the said James Webster, have hereunto set my hand and seal, this eleventh day of January, in the year of our Lord one thousand eight hundred and fifty-eight.

JAMES WEBSTER. [L. S.]

Witness:
GEORGE SHAW.

A. D. 1857. No. 2205.

Steam-Engines, &c.

Letters patent to William Hartley, of Bury, in the county of Lancaster, engineer, for the invention of "Improvements in Steam Engines and Steam Boiler Apparatus."

Sealed the 9th February, 1858, and dated 19th August, 1857.

Provisional specification left by the said William Hartley at the office of the Commissioner of Patents, with his petition, on the 19th August, 1857.

(Extract.)

I, William Hartley, of Bury, in the county of Lancaster, engineer, do hereby declare the nature of the said invention for "Improvements in Steam-Engines and Steam Boiler Apparatus" to be as follows:

* * * * * * *

Another of my improvements consists of a method by which a safety valve for steam-engine boilers is made to open, so as to discharge a volume of steam equal to the discharge of an unobstructed passage containing the same area as the passage through the valve-seat. This I accomplish in two ways: first, by constructing the valve with a projecting flange, on which is situate a curved external rim projecting downwards, the section of said valve and rim
100 being similar to the section of an inverted cup. When the valve is closed the external rim is nearly in contact with the valve-seat or its bearing; but when the valve is opened by the action of the steam, the distance of the rim from the valve-seat or its bearing is equal to the area of the passage in the valve-seat, thereby discharging its maximum quantity of steam.

The second method by which I accomplish a full discharge of steam is by making the projecting rim of a cylindrical form, and

the valve-seat or its bearing curved, so as to increase in diameter downwards. In this case, when the valve is closed, the bottom edge of the rim nearly touches the bottom part of the curved seat or bearing, and when the steam lifts the valve the space between the edge of the rim and bearing increases in area, and so effects a full discharge of steam as before. In either of the above arrangements the valve will close when the steam pressure becomes reduced below the load on the valve.

(Extract.)

Specification in pursuance of the conditions of the letters-patent filed by the said William Hartley in the Great Seal Patent Office on the 17th February, 1858.

To all to whom these presents shall come, I, William Hartley, of Bury, in the county of Lancaster, engineer, send greeting:

Whereas Her Most Excellent Majesty Queen Victoria, by her letters patent, bearing date the nineteenth day of August, in the year of our Lord one thousand eight hundred and fifty-seven, in the twenty-first year of her reign, did, for herself, her heirs, and successors, give and grant unto me, the said William Hartley, her special license that I, the said William Hartley, my executors, administrators, and assigns, or such others as I, the said William Hartley, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time, and at all times
101 thereafter, during the term therein expressed, should and lawfully might make, use, exercise, and vend within the United Kingdom of Great Britain and Ireland, the Channel Islands, and the Isle of Man, an invention for "improvements in steam-engines and steam boiler apparatus," upon the condition (amongst others) that I, the said William Hartley, my executors or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be informed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters patent:

Now know ye, that I, the said William Hartley, do hereby declare the nature of my said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement and accompanying drawings (that is to say):

* * * * *

Another of my improvements consists of a method by which a safety valve for steam-engine boilers is made to open, so as to discharge a volume of steam equal to the discharge of an unobstructed passage containing the same area as the passage through the valve-seat.

This I accomplished in two ways: first, by constructing the valve *a*, as shown at Fig. 8, with a projecting flange, on which is situate a curved external rim *b*, projecting downwards, the section of the said

valve and rim being similar to the section of an inverted cup, as shown in the drawing. When the valve is closed the external rim *b* is nearly in contact with the valve-seat *c* or its bearing *d;* but when the valve is opened by the action of the steam, the distance of the rim *b* from the valve-seat or its bearing is equal to the area of the passage in the valve-seat, thereby discharging its maximum quantity of steam. The rod *e* is extended into the interior of the boiler, and a weight attached thereto to agree with the pressure of the steam acting on the valve, as required.

(Here follows diagram, marked page 102.)

The second method by which I accomplish a full dis-
103 & 104 charge of steam is by making the projecting rim *b* of a cylindrical form, as shown in Fig. 9 of the accompanying drawings; the valve-seat *c*, or its bearing *d*, is curved, so as to increase in diameter downwards. In this case, when the valve *a* is closed, the bottom edge of the rim *b* nearly touches the bottom part of the curved seat or bearing, and when the steam lifts the valve the space between the edge of the rim and bearing increases in area, and so effects a full discharge of steam. The rod *e* is weighted as before mentioned.

In either of the before-mentioned arrangements the valve will close when the steam pressure becomes reduced below the load on the valve.

Having thus described the nature of my invention, and the manner in which the said invention is to be performed, I wish it to be understood that what I claim is—

* * * * * * *

Thirdly. The application to safety-valves of the several arrangements and combination of parts, as herein set forth.

In witness whereof, I, the said William Hartley, have hereunto set my [hand] and seal, this sixteenth day of February, in the year of our Lord one thousand eight hundred and fifty-eight.

WILLIAM HARTLEY, [L. S.]

Witness:

THOMAS BALDWIN,

Corn Market Buildings, Bury, Lancashire.

105 *Safety Valves.*

Letters patent No, 1038, dated 25th April, A. D. 1863, to Charles Beyer, of the firm Beyer, Peacock & Co., Gorton Foundry, Manchester, in the county of Lancaster, engineers, for the invention of "Improvements in Safety Valves." A communication from abroad by Johann Andreas Schubert, Professor of Engineering at the Polytechnic School at Dresden.

Sealed the 16th October, 1863, and dated the 25th April, 1863.

Provisional specification left by the said Charles Beyer at the office of the Commissioners of Patents, with his petition, on the 25th of April, 1863.

I, Charles Beyer, of the firm of Beyer, Peacock & Co., Groton

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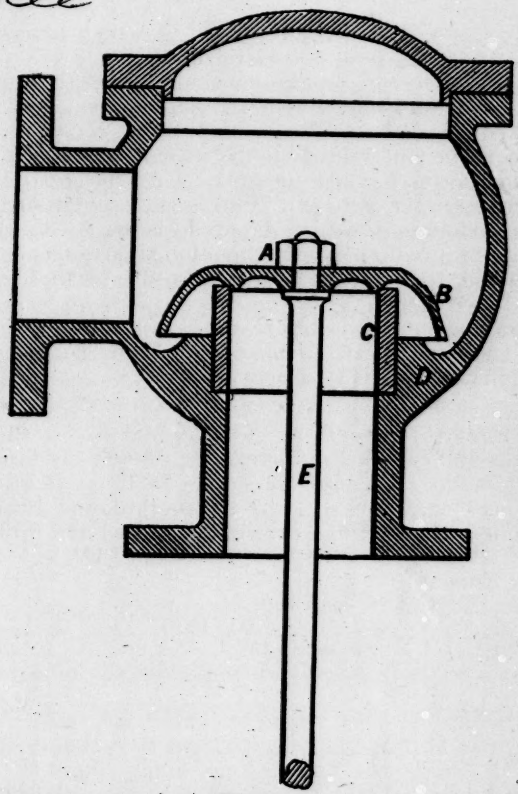

FIG. 8.
English Patent to WM. HANTLEY, No. 2,205, Aug. 19, 1857.

Foundry, Manchester, in the county of Lancaster, engineers, do hereby declare the nature of said invention for "Improvements in Safety Valves," communicated to me from abroad by Johann Andreas Schubert, Professor of Engineering at the Polytechnic School at Dresden, to be as follows:

It is well known that the common or ordinary safety valve when loaded to counterbalance a given pressure of steam, does not lift or blow off freely until the pressure has increased to a considerable extent above the pressure fixed upon; consequently the boiler is but slowly relieved of the excess of pressure, owing to the small area of the opening of the valve.

The object of this invention is wholly or partially to remove this defect, by causing the safety valve, when the pressure has become sufficient to overcome the weight upon it, to lift much higher than the ordinary safety valve, and thus give a larger opening for the escape of the steam or other fluid.

This invention consists in forming a flange round the valve, commencing at the outer edge of the valve-facing, which flange is undercut, and concave in shape, and the concave side is towards
106 the seating of the valve, which has also a flange upon it, commencing at the outer edge of the valve-seating; but the upper surface of this flange is convex, and corresponds nearly to the concave surface of the flange upon the valve. There is a slight space between the concave and convex surfaces of the two flanges, which diminishes towards the outer edge of the flanges. When the steam begins to escape from between the surfaces of the valve it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area, and reacts upon the concave surface of the valve, and causes it to open to a greater extent than the ordinary valve.

Specification in pursuance of the conditions of the letters patent filed by the said Charles Beyer in the Great Seal Patent Office, on the 21st October, 1863.

To all to whom these presents shall come:

I, Charles Beyer, of the firm of Beyer, Peacock & Co., Gorton Foundry, Manchester, in the county of Lancaster, engineers, send greeting:

Whereas Her Most Excellent Majesty Queen Victoria, by her letters patent, bearing date the twenty-fifth day of April, in the year of our Lord one thousand eight hundred and sixty-three, in the twenty-sixth year of her reign, did, for herself, her heirs, and successors, give and grant unto me, the said Charles Beyer, her special license that I, the said Charles Beyer, my executors, administrators, and assigns, or such others as I, the said Charles Beyer, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time, and at all times thereafter, during the term therein expressed, should, and lawfully might, make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for

"improvements in safety valves," a communication from Johann Andreas Schubert, professor of engineering at the polytechnic school at Dresden, upon the condition (amongst others) that I, the said Charles Beyer, by an instrument in writing, under my hand and seal, should particularly describe and ascertain the nature of
107 the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calender months next and immediately after the date of the said letters patent.

Now know ye that I, the said Charles Beyer, do hereby declare the nature of my said invention, and in what manner the same is to be performed, and to be particularly described and ascertained in and by the following statement and accompanying drawings, that is to say:

It is well known that the common or ordinary safety valve, when loaded to counterbalance a given pressure of steam, does not lift or blow off freely until the pressure has increased to a considerable extent above the pressure fixed upon; consequently the boiler is but slowly relieved of the excess of pressure, owing to the small area of the opening of the valve.

The object of this invention is wholly or partially to remove this defect by causing the safety valve, when the pressure has become sufficient to overcome the weight upon it, to lift much higher than the ordinary safety valve, and thus give a larger opening for the escape of the steam or other fluid.

This invention consists in forming a flange round the valve, commencing at the outer edge of the valve facing, which flange is undercut and concave in shape, and the concave side is towards the seating of the valve, which has also a flange upon it, commencing at the outer edge of the valve seating, but the upper surface of the flange is convex, and corresponds nearly to the concave surface of the flange upon the valve. There is a slight space betweeen the concave and convex surfaces of the two flanges, which diminishes towards the outer edge of the flanges. When the steam begins to escape from between the surfaces of the valve, it gets between the concave and convex surfaces of the two flanges, and its force thus acts upon a larger area, and reacts upon the concave surface of the valve, and causes it to open to a greater extent than the ordinary safety valve.

The accompanying sheet of drawings shows a sectional elevation of a valve formed according to the invention.

(Here follows diagram, marked page 108.)

a is the flange from the seating, having the convex sur-
109 & 110 face towards the valve, and *b* the flange upon the valve, having the concave surface towards the seating of the valve; *c*, valve spindle; *d*, valve lever; d^1, its fulcrum. This improved valve will, as before stated, lift promptly when the required pressure is attained, and will open to a much greater extent than the common safety-valve. Extra pressure upon the valve will readily close it

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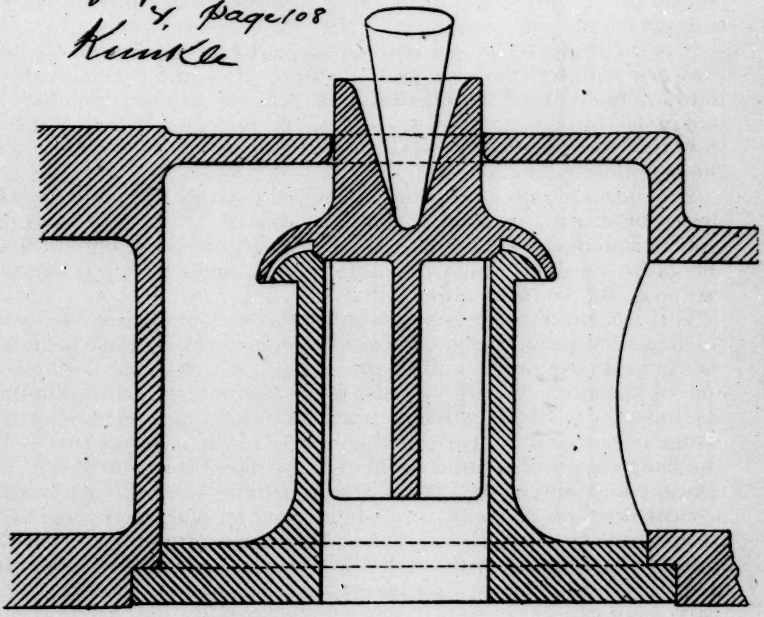

English Patent to Chas. Beyer, No. 1,038, April 28th, 1863.

after it has lifted, but it does not shut, self-acting, till the pressure in the boiler has diminished several pounds below the pressure at which the valve was lifted. To cause the safety valve, when it has been lifted by the excess of pressure, to close again, self-acting, when the pressure has diminished to a given extent, the inventor employs the additional apparatus which is also shown upon the accompanying drawings, in connection with his improved valve. It will be seen that the valve is enveloped by a pipe or hood (*e*), which serves to conduct away the steam escaping from the valve, the outlet for this steam being at e^1. This hood has a hole in it through which the top of the valve passes; it has also another hole at e^2, which communicates with passages in a conical plug *f*, in communication with a vertical pipe *g*, the conical plug forming a joint for the vertical pipe to swivel upon. The vertical pipe is screwed into the upper side of a cylindrical vessel g^1, and another pipe g^2, which is bent as shown, screws into the lower side of the vessel g^1, and the other end of this bent pipe screws into the lower side of another cylindrical vessel *h*, which has a double valve-box h^1 screwed into its upper side, as shown. The valve-box contains a spindle, *k*, with reversed cone facings, one for the upper, the other for the lower valve-seating. The upper end of the valve-spindle *k* is screwed, and has an adjusting screw k^1 upon it, the shoulders of which rest upon a forked bracket k^2, secured to the hood (*e*), as shown, Each end of the cylindrical vessel *h* has a pivot formed upon it, and one end of a link *l* is jointed upon each pivot; the other end of the links are jointed with a cross pin d^2 fixed on the end of the lever *d*. It will now be seen that the cylindrical vessels g^1 and *h*, and their connected parts, are sustained partly upon the lever *d* and the swivel cone plug *f*, and when the safety valve is shut, the screw k^1 is adjusted so that the cone on the spindle *k* for the lower valve
111 will just be open, in which position the air can enter the vessel *h*. The vessel *h* is at a higher level than the vessel g^1, which is filled with mercury, which communicates by the pipe g^2 with the vessel *h*, but only reaches to its lower side when the safety valve is closed, and the steam is not escaping, When the safety valve opens, the end of the lever *d* will lift, and with it the vessel *h* and its connected parts. The vertical pipe *g*, and connected vessel g^1, will also turn slightly upon the swivel conical plug *f*. The valve-spindle *k* will then be sustained upon the lower valve-seating (or so much of its weight as remains unbalanced by the buoyant power of the mercury), and as the pressure of the escaping steam will act upon the surface of the mercury of the vessel g^1, it will be forced into the vessel *h*, and by this means an increased load will be put upon the valve-lever *d*. Should the mercury rise into the valve-box h^1, its escape will be prevented by the rise of the valve-spindle *k* till it comes against the upper valve-seating, as the spindle is of such proportions and so arranged as to descend into the mercury, so as to float when the mercury ascends sufficiently high in the vessel. If the pressure of the steam diminishes so as not to sustain the mercury in the vessel *h*, then when a part has run back, the valve-spindle *k* will descend, and will rest upon the lower seating and

prevent the admission of air, and consequently the escape of mercury from the vessel till the safety valve closes, when the lever *d*, vessel *h*, and connected parts will descend, and the adjusting screw-nut k^1 of the valve-spindle *k* will rest on the forked bracket k^2, in which position the valve is opened; consequently the remainder of the mercury in the vessel will be permitted to return to the vessel g^1. If preferred, the vessel *g* might be placed on the fulcrum of the lever *d*, and the vessel *h* at the end of the lever *d*, communicating by a pipe (g^2), the arrangement of the other parts being modified accordingly. In place of mercury, water or other fluid may be used, the capacity of the vessels g^1 and *h* being made sufficiently large.

I have now particularly described the nature of the invention communicated to me, and the mode of carrying the same into effect, and wish it to be understood that I claim—

112 Firstly. The construction of safety vales with flanges substantially in the manner and for the purpose hereinbefore described.

Secondly. Apparatus for self-closing safety valves after they have been lifted by the pressure of the steam or fluid, as hereinbefore described.

In witness whereof, I, the said Charles Beyer, have hereunto set my hand and seal, this sixteenth day of October, in the year of our Lord one thousand eight hundred and sixty-three.

CHARLES BEYER. [L. S.]

Apparatus for Preventing the Explosion of Steam-Boilers.

Specification in pursuance of the conditions of the letters patent filed by the said Thomas Green, in the Great Seal Patent Office, on the 9th November, 1859.

To all to whom these presents shall come, I, Thomas Green, junior, of Old Broad street, in the city of London, send greeting:

Whereas Her Most Excellent Majesty Queen Victoria, by her letters patent, bearing date the ninth day of May, in the year of our Lord one thousand eight hundred and fifty-nine, in the twenty-second year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said Thomas Green, my executors, administrators, and assigns, or such others as I, the said Thomas Green, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time, and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for "improvements in apparatus applicable to steam-boilers, to obtain greater security against explosion," upon the condition (amongst others) that I, the said Thomas Green, my executors or administrators, by an instrument in writing, under

113 my, or their, or one of their, hands and seals, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the

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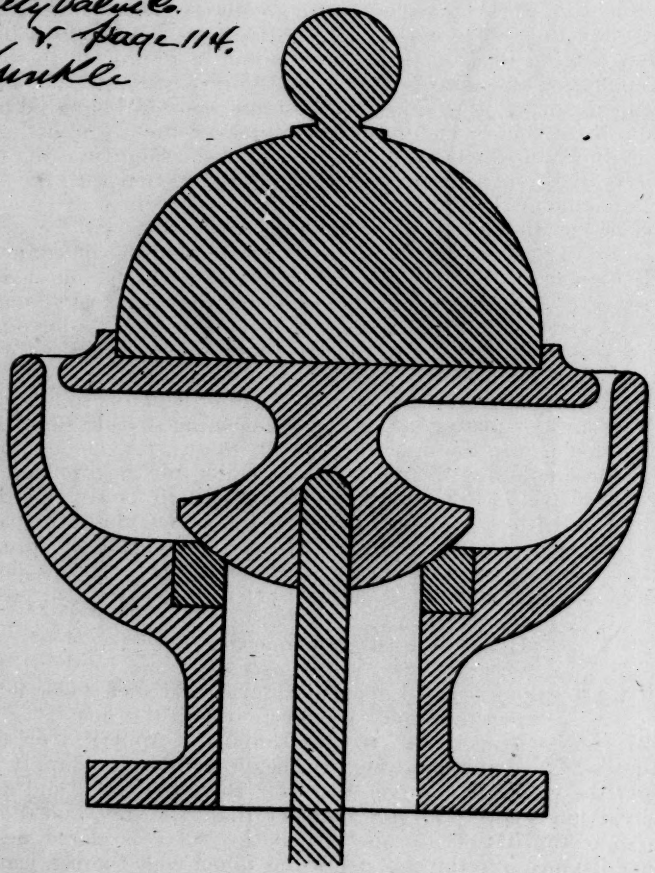
PLATE 5.



English Patent to Thos. Green, Jr., No. 1,165, November 9, 1850.

same to be filed in the Great Seal Patent Office within six calender months next and immediately after the date of the said letters patent.

Now know ye, that I, the said Thomas Green, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof (that is to say):

This invention has for its object improvements in apparatus applicable to steam-boilers, to obtain greater security against explosion. For these purposes, the feed-water, in its passage to a steam-boiler, acts on a piston in such a manner as to prevent the piston being pressed downwards, which, in itself, is not new; but in this arrangement the other side of the piston is constantly pressed on by steam, there being a communication between the steam-boiler and the cylinder in which the piston works; at the same time, the steam is prevented from sounding a whistle, in connection with the cylinder, so long as the supply of water is properly kept up; so soon, however, as the supply of water fails, the piston will be pressed down by the steam, and a valve of a steam-whistle (in connection with a piston) will be opened, and the whistle will be sounded by a passage of steam through it. In order that the piston may be allowed to descend or move as early as possible after the force-pump has ceased to supply water properly, there is a small outlet through which water is constantly allowed to escape, and such outlet is, by preference, through a cone, the upper end of which is small, so that no substance or matter can rest on the opening so as to stop it.

Another part of the invention consists in an arrangement of apparatus for conducting the steam from a boiler into the fireplace, when the water-level in the boiler falls below a certain point, and this is accomplished by means of a plug or valve which closes the passage of a pipe leading from the upper part of the boiler to the fireplace.

This plug or valve is arranged to be opened when a float in the boiler descends to a certain extent. For this purpose the

(Here follows digram, marked page 114.)

115 & 116 plug is acted upon by a lever, and such lever is acted upon by a rod in connection with the float.

In constructing a safety-valve, having a spherical or curved under surface (whether weighted below or above), I apply a disc above the valve, of a larger diameter than the valve, and around the valve is a cup of larger diameter than the disc, and the parts are so arranged that the disc, when the valve is closed, descends some distance into the cup, below the upper edge thereof, leaving a small space between the edge of the periphery of the disc and the interior of the cup.

Having thus stated the nature of my invention, I will proceed more fully to describe the manner of performing the same.

Description of the Drawings.

Figure 1 shows a section of apparatus constructed and combined according to my invention.

Figure 2 is a plan thereof, partly in section; and figure 3 is a transvere section thereof. *a* is the inlet, connected with the force-pump for supplying water to a boiler, the water passing freely into the boiler so long as the passage is open thereto, by the float and valve used for that purpose, and the water passes through the outlet *b*, to the boiler, or to an escape outlet, when the supply is not required to the boiler; *c* is a steam inlet communicating constantly with the boiler, so that there will be a constant pressure of steam on the piston *d*, tending to force it downwards, whilst the pressure of water, if properly and continuously supplied by the force-pump, will press on the under side of the piston *d*, and prevent its descending; but should any defect in the force-pump, or other cause, render the supply of water insufficient, then the pressure of the steam on the upper side of the piston *d* will prevail, and the piston will be caused thereby to descend and open the valve *e* to the whistle *f*. The apparatus is arranged in such manner that the piston *d* may descend a distance before it acts on the stem of the valve *e*, and this distance may be greator or less, according to the desire of the parties applying the apparatus. *g* is a conical nipple, through which there is
117 a constant outgoing of a small quantity of water. This cone is covered by a perforated shield, in order to prevent any matter getting to the conical outlet which would clog it; by this arrangement, should the force-pump cease to supply sufficient water a quantity of the water would continue to escape through the nipple, and the piston would immediately descend. I would state that it is not new to cause the water fed to press on a piston so as to prevent a whistle being sounded; I do not, therefore, claim the same, and I would state that the peculiar character of this part of the invention consists in the combination of the parts *a*, *c*, *d*, and *g*.

In order to convey the steam of a steam-boiler into the ash-pit when the water falls below a certain point, and thus to damp the fire and relieve the pressure on the boiler by allowing the steam to blow off, I employ an apparatus such as is shown at figure 4, where *h* is a float in a steam-boiler in connection with a lever *i*, also within the boiler. The other end of this lever acts on a slide valve *j*, or it may be arranged to act on any other suitable slide or valve; *k* is an outlet which is connected with the ash-pit of the boiler furnace, by which arrangement, when the water level in the boiler sinks, the valve *j* will be opened and the steam will escape to the ash-pit.

I would state that this part of the invention consists in the combination of mechanical parts herein described. Figure 5 shows a safety valve and apparatus constructed and combined according to another part of my invention; *l* is a valve having a spherical under-surface; *m* is a disc of larger diameter than the valve so that any steam escaping beyond the valve will tend to press the disk and valve upwards; *n* is a cup, the upper edges of which rise somewhat above the disc, and there is a small space below the inner surface of the

cup, and the outer edge of the disc; *o* is a weighted rod to the valve, and the disc is also shown to be weighted. I would state that the peculiarity of this part of my invention consists in the combination of the parts *l*, *m*, and *n*, as herein described.

In witness whereof, I, the said Thomas Green, have hereunto set my hand and seal, this ninth day of November, in the year of our Lord one thousand eight hundred and fifty-nine.

THOMAS GREEN, JR. [L. S.]

118 *Safety Valves.*

Letters patent No. 1,830, dated July 21st, A. D. 1863, to William Naylor, of Queen's Road, Dalston, in the County of Middlesex, engineer, for the invention of "Improvements in Safety Valves, and in apparatus connected therewith."

Sealed the 19th January, 1864, and dated the 21st July, 1863.

Provisional specification left by the said William Naylor at the Office of the Commissioners of Patents, with his petition, on the 21st July, 1863.

I, William Naylor, of Queen's Road, Dalston, in the County of Middlesex, engineer, do hereby declare the nature of the said invention for "Improvements in safety valves, and in apparatus connected therewith," to be as follows:

This invention relates to certain improvements in safety valves, and consists in the employment of valves (when used with levers loaded by dead weights), having the edges of the valve outside the valve-seating cupped or turned downwards, so that the main body of the steam as it escapes from the boiler, being directed downwards, strikes against the bottom of a suitable recess, or into a chamber round the pipe leading from the boiler to the valve; and consequently the recoiling action of the steam acts upward against the under surface of the valve as it issues forth into the atmosphere, and by such recoiling action of the steam the valve is assisted in opening, so as to counteract the resistance of the atmosphere to the issuing steam, which resistance is virtually equal to an extra load on the valve; or the edges of the valves may project horizontally beyond the valve-seat, so that the steam, after leaving the valve-facing, may act under the projection as it rushes into the atmosphere, virtually acting on a larger valve surface after leaving the boiler, and before its final exit into the atmosphere. When using a spring for resisting the valve from opening, I propose using a lever of the first order, one end resting by a suitable pin upon the safety valve,
119 and the other end of the lever resting upon the spring. The end resting upon the spring I propose bending downwards about 45 degrees, so that when the valve is raised by the steam the other end of the lever is depressed upon the spring downwards, and at the same time is moved inwards towards the fulcrum, thus virtually shortening that end of the lever, and thereby counteracting the additional load upon the valve as it is raised from its seat by

the greater amount of compression put upon the spring. In some cases I propose placing the spring in tension, and acting at right angles to the valve-lifting. In some cases I propose to employ a cylinder with a piston acting against the spring, resisted by the end of a lever projecting over from the valve; the compression of this spring will indicate the pressure of the steam in the boiler, and when the maximum pressure is attained it will assist in lifting the valve.

Specification in pursuance of the conditions of the letters patent filed by the said William Naylor in the Great Seal Patent Office, on the 21st January, 1864.

To all to whom these presents shall come:

I, William Naylor, of Queen's Road, Dalston, in the County of Middlesex, engineer, send greeting:

Whereas Her Most Excellent Majesty Queen Victoria, by her letters patent, bearing date the twenty-first day of July, in the year of our Lord one thousand eight hundred and sixty-three, in the twenty-seventh year of her reign, did, for herself, her heirs and successors, give and grant unto me, the said William Naylor, her special license that I, the said William Naylor, my executors, administrators, and assigns, or such others as I, the said William Naylor, my executors, administrators or assigns, should at any time agree with, and no others, from time to time, and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an invention for "Improvement in Safely Valves, and an Apparatus connected therewith," upon the condition (amongst others) that I, the said William Naylor, my executors or administrators, by an instrument in writing, under my hand and seal, or under the hand and seal of one of them, should particularly describe and ascertain the nature of the said invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said letters patent.

Now know ye, that I, the said William Naylor, do hereby declare the nature of my said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement, reference being had to the accompanying drawings, and to the letters and figures marked thereon, that is to say:

My said invention relates to certain improvements in safety valves, and consists, when using a spring for resisting the valve from opening, in the employment of a lever of the first order, one end resting by a suitable pin upon the safety-valve, and the other end of the lever resting upon the spring, the end resting upon the spring being bent downwards to an angle of about 45° from the fulcrum, so that when the valve is raised by the steam the other end of the

lever is depressed upon the spring downwards, and at the same time is moved inwards towards the fulcrum, thus virtually shortening that end of the lever, and thereby counteracting the additional load upo the valve as it is raised from its seat by the greater amount of compression put upon the spring. In some cases I propose placing the spring in tension, and causing it to act at right angles to the valve. I also propose to employ a cylinder with a piston acting against a spring, resisting by the end of a lever projecting over from the valve; the compression of this spring will indicate the pressure of the steam in the boiler, and when the maximum pressure is attained it will assist in lifting the valve.

And in order that my said invention may be fully understood, I shall now proceed more particularly to describe the same, and for that purpose I shall refer to the several figures on the sheets of drawings hereunto annexed, the same letters of reference indicating corresponding parts throughout all the figures.

121 Figure 1 on sheet 1 of my drawings represents a vertical section of a safety valve provided with my improved compensating valve lever; Figure 2 is a sectional plan taken along the line 1, 2, in Figure 1; Figure 3 is a front elevation of the valve complete; and Figure 4 is an elevation of the opposite side of the valve to that shown in Figure 3.

A is the main thoroughfare leading direct from the boiler; B is a laterial branch or escape passage for a portion of the steam after it has passed the valve C. I prefer to make this valve project over the edges of the exit passage A, and to curve the projecting edges of the valve slightly downwards, as shown in the drawing (Figure 1), so that the steam on issuing between the valve and its seat will impinge against the curved projecting portion of the valve, and a portion of it will be directed downwards into the annular chamber D, surrounding the central passage A, which chamber D communicates at once with the branch exit-pipe B, whilst the other portion of the steam ascends past the edges of the valve. By this means I am enabled to avail myself of the recoil action of the steam against the valve for the purpose of facilitating the further lifting of such valve when once opened; but I wish it to be understood that I lay no claim to such recoil action, nor to the extension of the valve laterally beyond its seat. E is my improved valve-lever; it works on a ful- crum at F, and is made to hold down the valve at one end throu the rod or spindle G, by the action of the helical spring H, wh exerts an upward pressure against the opposite end *a* of the This end *a* of the lever is bent downwards, as shown in my ing, and is acted upon directly by the upper end of a rod o ver. I, situate inside the coils of the spring H. and provided wit raw- or collar *b*, against which the upper end of the spring spindle lower end of the spring resting upon a crossbar K thr a flange in the centre of which the lower end of the spindle I bears, the free to move vertically. If preferred, the rod or s gh a hole, dispensed with, the upper end of the spring H be guided, and bear directly against the lever, whilst the lower dle I may be g turned up to d may either lay

in a sunk bed in the crosshead, or to be turned down to form a contact or centre bearing point.

(Here follows diagram, marked page 122.)

123 & 124 Figure 4ª is a detail showing another modification of the mode of fitting or adapting the spring or springs H. *a* is the bent end of the lever E shown in Figure 1; *b* is a nipple or centre point, which is pressed against the end *a* of the lever by one or more springs H H¹. The lower ends of these springs bear against a similar nipple or centre point *c*, which rests in a countersink in the crossbar K, or in the end of an adjusting screw *d* passing through the crossbar, so that by raising or lowering the screw the resistance of the spring or springs may be regulated; L L are two long bolts, which pass down through corresponding sockets M M cast on the valve-casing, and through corresponding bolt-holes near each end of the crossbar K, which is thus supported entirely by the two bolts. By tightening more or less the bolts L by their nuts, the spring H may be compressed to any desired extent between the crossbar K and the collar or flange *b* on the spindle I. The operation of the peculiar bent lever is as follows: so soon as the pressure in the boiler overcomes the resistance of the spring H the valve is lifted, and a certain extra compression is put on the spring. The increasing compression of the spring during the opening of the valve has a tendency, if no compensating means are employed, to check the full opening of the valve so as to afford an escape orifice equal in area to that of the passage A, but by bending down the lever, as shown at *a*, the lifting of the valve tends to draw that end of the lever toward the fulcrum, thereby virtually shortening that end of the lever; consequently the power of the lever to compress the spring is increased in proportion as the valve is elevated, or, in other words, the resistance of the spring is proportionately diminished. When the apparatus is properly constructed, the resistance against the lifting valve will be uniform, or nearly so, in whatever position the apparatus may be.

Figure 5 is a vertical section, showing the application of the valve arrangement of compensating lever and springs to a safety-valve of another Figure 6 is a sectional plan of the same; and Figure 7 is a detail of the apparatus. In this arrangement the bent lever E, of the safety-valve; beyond the valve, as shown at *c*, and through this end view slides freely a rod or spindle N, provided with is continued
125 lar *d* near its lower end, and with a piston or of the lever latter working steam-tight inside a small cylinder flange or collar cylinder is in direct communication, through the passage plunger O, the interior of the boiler. Q is a helical spring surrounding the spindle N, and pressing at its upper end against the passage *c*, with the valve-lever E, whilst its lower end abuts against the rod or *d*. In all other respects the valve and parts connected with the end *c* of the are the same as in the arrangement previously described and illustrated by Figures 1, 2, 3, and 4, with the exception that, in lieu of the bearing points at the parts above, the lever E is in contact with

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FIG. 1.
English Patent to WM. NAYLOR, N. 1,880, July 21, 1803.

the spindles G and I; ordinary pin-joints are shown connecting such spindles to the lever. By adopting a vertically sliding indicator to the rod or spindle N, in combination with a properly graduated scale or divided plate, the pressure of the steam in the boiler, per square inch, can be readily indicated. As the pressure increases the piston O rises, and the spring Q is compressed, the upper end of the rod or spindle N working freely through the end *e* of the valve lever. So soon as the steam attains its regulated maximum pressure, the resistance of the spring H against the bent end *a* of the lever E will be overcome by that of the spring Q against the opposite end of the lever, together with the pressure under the valve, and the valve C will consequently open, and will be assisted in its opening by the action of the spring Q, whilst at the same time the increasing resistance of the spring H is compensated by the action of the bent end *a* of the lever hereinbefore described. The spring H should of course be made sufficiently strong to resist the regulated pressure upon the area of the valve C as well as the pressure of the spring Q, so as to allow the steam to escape at its maximum pressure only. Figures 1, 2, and 3, on sheet 2 of my drawings, represent similar views of a similar arrangement of compensating safety-valve lever to that illustrated by Figures 5, 6, and 7, already referred to, the only difference being in the means employed for indicating the steam pressure in the boiler. In this arrangement I have shown the valve C of the ordinary construction, the whole of the escape-steam passing upwards. A vertical sliding indicator was hereinbefore described as being employed in connection with the rod or spindle N, but in the
126 arrangement shown on sheet 2 of my drawings I have illustrated a revolving indicator and a circular dial. E is the valve lever, through the end *e* of which works freely the upper end of the rod or spindle N. This end of the rod has a series of rings *f* turned thereon, or is provided with ordinary rack teeth, which gear into a small spur pinion *g* fast on one end of a short spindle *h*, which revolves freely in a socket or tubular bearing *i*, carried by the lever E. To the opposite end of the spindle *h* is fitted an indicator or pointer *k*, which indicates on the face of the circular dial *l*, secured to the outer end of the socket or tubular bearing *i*, the pressure of the steam, per square inch, inside the boiler. The piston O, in place of being made in one piece with the rod or spindle N, is separate therefrom and presses against the rod by a centre point arrangement shown at *m*. The steam passage *e*, leading to the cylinder, is curved so as to open laterally from the main thoroughfare A of the valve.

Having now described and particularly ascertained the nature of my said invention, and the manner in which the same is or may be used or carried into effect, I would observe, in conclusion, that what I consider to be novel and original, and therefore claim as the invention secured to me by the hereinbefore in part recited letters patent, is:

First. The general construction and arrangement of compensating safety-valves substantially as hereinbefore described.

Second. The application and use to and in safety-valves of bent

levers of the first order acting in combination with a spring or springs, substantially in the manner and for the purpose hereinbefore described.

Third. The use in combination with a spring or springs and bent safety-valve lever of the first order of a cylinder piston, piston rod, and additional spring, acting substantially in the manner and for the purpose hereinbefore described.

In witness whereof, I, the said William Naylor, have hereunto set my hand and seal, the eighteenth day of January, one thousand eight hundred and sixty-four.

WILLIAM NAYLOR. [L. S.]

127 *The Waterman Patent. Safety Valves.*

The schedule referred to in these letters patent, and making part of the same:

To all whom it may concern:

Be it known that I, Henry Waterman, of the city of Hudson, county of Columbia, State of New York, have invented a new and improved mode of constructing the safety valves of locomotive engines, and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings and letters of reference marked thereon:

Owing to the jolting of the locomotive engine when in motion, it was found necessary at an early day to discard the use of the simple weight upon the lever of the safety valves, as large portions of steam would be blown off when the pressure was below the point indicated by the mean pressure of the weight upon the valve, as, for instance, when the boiler was suddenly thrown upward the weight would continue to go up, so that by the recoil and momentum the valve would be a portion of the time raised from its seat, and the steam allowed to blow off when below the desired point of pressure, the spring balance was substituted and has been generally used or applied to the lever of safety valves.

It has been long known that the spring balance is an imperfect indication of the pressure of steam from the following causes:

The safety-valve, in raising, will raise the outer end of the lever that rests upon, though a much greater distance than the valve itself as the proportions of power of the lever, as for instance, a lever of a power of twelve times, resting on a valve, say two inches in diameter, when the valve is raised to its full capacity, say one-half inch, will raise its outer end six inches; a distance quite impossible with an ordinary spring balance, without greatly increasing the pressure balance; consequently at the same time increasing the pressure of the steam, so that it will be seen an adequate discharge cannot take

(Here follows diagram, marked page 128.)

129 & 130 place with a spring balance resting upon. Taking another instance: suppose a valve to raise one-eighth of an inch, which allows an escape of about one-fourth the capacity of

PLATE 4.

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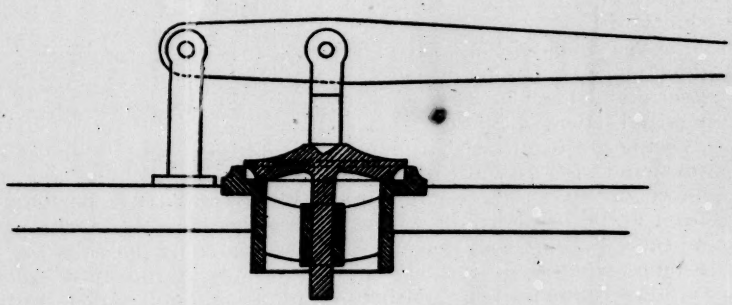

THE WATERMAN VALVE.

U. S. Letters Patent, No. 10,243, November 15th, 1853.

the valve, the outer end of the lever will raise one and a half inches. If to this a spring balance is attached, with a scale of one-twentieth of an inch to the pound, it is evident that the pressure will be increased thereby thirty pounds per inch. To remedy this difficulty I propose to use the simple weight and lever, so as to attain, as near as possible, a constant and uniform pressure upon the valve, and in order to prevent the vibrations of the weight and lever I apply to outer end of lever a rod that descends vertically, by which the weight is suspended to lever; at the bottom of said rod, below the weight, attach a small piston of about three inches diameter; surrounding this piston I place a cylinder, in which this piston is allowed to move freely and easily; the cylinder is firmly attached to boiler or other convenient parts; into this cylinder I put a fluid—mercury, oil, alcohol, or water—I prefer good sperm oil. This fluid must fill the cylinder to near the top, so as to completely cover the piston. It is evident that the piston can move no faster than the fluid is made to pass by the piston, and it will check all sudden vibrations, yet freely pass to a position due to pressure, etc. By having an adequate facility of discharging surplus steam we have succeeded in securing an uniform temperature and pressure in the locomotive boiler, preventing almost entirely the difficulty of leakage of tubes, riveted joints, so commonly caused by these variations; also design it as a sure preventive of explosion from these causes.

Description of Drawing.

A represents the rear part of boiler.
B the ordinary safety valve.
C the ordinary lever.
D the weight.
E the rod upon which the weight is suspended to lever.
F the piston attached to rod E.
G the cylinder, in which the piston F is allowed to move freely.
131 H is a stand by means of which the cylinder is attached to boiler A.
I I I I represents the fluid in cylinder G which covers the piston F.

What I claim as my improvement, and desire to secure by letters patent, is the piston F, attached to the weighted end of the valve lever within the cylinder G, and immersed in the liquid in the cylinder combined and operating in the manner and for the purposes herein described.

HENRY WATERMAN.

Witnesses:
DARIUS PECK.
JAMES CLARK.

Richardson Patent.

Letters patent of the United States, No. 58,294. Granted George Wm. Richardson, of Troy, N. Y., September 25, 1866. Improvement in safety valves. The schedule referred to in these letters patent, and making part of the same.

To all whom it may concern:

Be it known that I, George W. Richardson, of the city of Troy, in the county of Rensselaer, in the State of New York, have invented a new and useful improvement on a safety valve for steam generators; and I do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same, reference being had to the annexed drawings, making a part of this specification, in which—

Fig. 1 is an end view of my improved safety valve and its seat, as seen from the bottom.

Fig. 2 is an end view of the valve alone, as seen from the bottom.

Fig. 3 is a vertical section, at *x x*, Fig. 1, of the valve and seat in position.

(Here follows diagram marked page 132.)

133 & 134 Fig. 4 is a vertical section at *y y*, Fig. 2, of the valve alone. Similar colors and letters of reference indicate corresponding parts in the several figures.

A A is the head of the safety valve.

B, B, B, B, are wings to guide the valve into its seat E E.

c c is a circular or annular flange or lip extending over, slightly below, and fitting loosely around the outer edge of the valve seat E E.

D D is a circular or annular chamber into which the steam immediately passes when the valve lifts from its seat at the ground joint F F.

E E is the valve seat.

F F is the ground joint of the valve and seat.

P is the counter-sink, or centre upon which the point of the stud extending from the scale-lever rests in the usual manner.

The nature of my invention consists in increasing the area of the head of the common safety valve outside of its ground-joint, and terminating it in such a way as to form an increased resisting surface, against which the steam escaping from the generator shall act with additional force after it has lifted the valve from its seat at the ground joint; and so, by overcoming the rapidly increasing resistance of the spring or scales, insure the lifting of the valve still higher, thus affording so certain and free a passage for the steam to escape as effectually to prevent the bursting of the boiler or generator, even when the steam is shut off and the damper left open.

To enable others, skilled in the art, to make and use my invention, I will proceed to describe its construction and operation. To the head of the common safety valve, indicated by all that portion of Fig. 2 lying within the second circle from the common centre, I add

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G. W. Richardson,

Steam Safety Valve.

No 58,294. Patented Sep. 25, 1866.

Fig 1

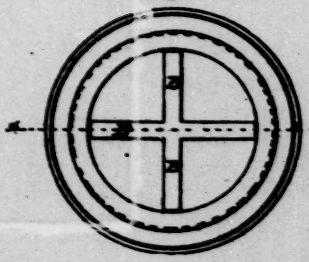


Fig 2

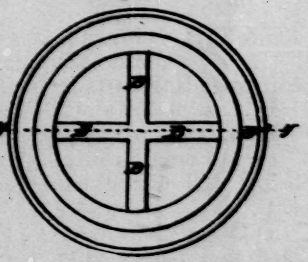


Fig 3

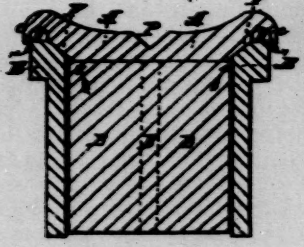
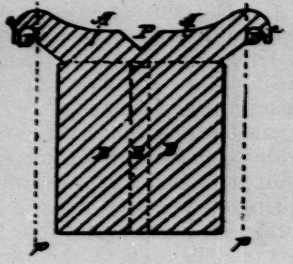


Fig 4



Witnesses
Clifford
A. H. Parker

Inventor.
Geo. W. Richardson

what is indicated by all that portion lying outside of the said circle, in about the proportion shown in the figure. A transverse, vertical section of this added portion is indicated in Fig. 4, by those portions of the figure lying outside of the dotted lines *p p*, *p p*, while all that portion lying within the dotted lines *p p*, *p p*, indicates a transverse vertical section of the common safety valve alone. This increased area may be made by adding to a safety valve already in use, or by casting the whole entire.

135 I terminate this addition to the head of the valve with a circular or annular flange, or lip, *c c*, which projects beyond the valve seat E E, Fig. 3, and extends slightly below its outer edge, fitting loosely around it and forming the circular or annular chamber D D, whose transverse section, shown in the figure, may be of any desirable form or size. This flange, or lip, *c c*, fitting loosely around the valve seat E E, is separated from it by about $\frac{1}{64}$ of an inch for an ordinary spring or balance. For a strong spring or balance this space should be diminished, and for a weak spring or balance it should be increased to regulate the escape of the steam as required. Instead of having the flange, or lip, *c c*, project beyond, and extend below and around the outer edge of the valve seat, as shown in Fig. 3, a similar result may be attained by having the valve seat itself project beyond the outer edge of the valve head, and terminating it with a circular or annular flange or lip, extending slightly above and fitting loosely around the outer edge of the flange, or lip, *c c*, of the valve head; but I consider the construction shown in Fig. 3 preferable.

With my improved safety valve, constructed as now described, and attached to the generator in the usual way, the steam, escaping in the direction indicated by the arrows in Fig. 3, first lifts the valve from its seat at the ground joint E F, and then passing into the annular chamber D D, acts against the increased surface of the valve head, and by this means, together with its reaction produced by being thrown downwards upon the valve seat E E, it overcomes the rapidly increasing resistance of the spring or balance, lifts the valve still higher, and escapes freely into the open air until the pressure in the generator is reduced to the degree desired, when the valve will be immediately closed by the tension of the spring or balance. The escape of the steam, by means of this safety valve, is so certain and free, that the pressure of the steam in the generator or boiler will not increase beyond the point or degree at which the valve is set to blow off.

What I claim as my improvement, and desire to secure by letters patent, is a safety valve with the circular or annular flange,
136 or lip, *c c*, constructed in the manner, or substantially in the manner, shown, so as to operate as and for the purpose herein described.

GEORGE WM. RICHARDSON.

Witnesses:
GEO. GOULD.
WM. H. POOR.

Richardson Patent.

Letters patent of the Unitey States, No. 85,963, granted George Wm. Richardson, of Troy, N. Y., January 19, 1869. Improvement in safety valves. The schedule referred to in these letters patent, and making part of the same.

To all whom it may concern:

Be it known that I, George William Richardson, of Troy, in the State of New York, have invented certain new and useful improvements in safety valves for steam boilers or generators; and I do hereby declare that the following is a full, clear and exact description thereof, reference being had to the accompanying drawings, making part of this specification, in which—

Figure 1 is a vertical section of the safety-valve and its connections, taken in the plane of the axis of the valve-stem; Fig. 2, a horizontal section taken in the plane of the line A *a* of Fig. 1; and Fig. 3, another horizontal section at the line B *b* of Fig. 1. Fig. 4 is a vertical section taken in the plane of the axis of the valve, representing a modification of my said invention; and Fig. 5, a horizontal section thereof, taken in the plane of the line C *c* of Fig. 4.

My said invention relates to improvements in the invention described in letters patent granted to me, and bearing date the 25th day of September, 1866, which said patented invention relates to a means for providing a more free escape for the steam than could be obtained by safety valves as constructed prior thereto, and to insure the keeping of the valve open until the pressure of the steam
137 in the boiler or generator falls below the pressure which was required to open it; the said means so patented consisting in forming the valve with a surface outside of the ground-joint, for the escaping steam to act against, the said surface being surrounded by a projecting or overlapping lip, rim, or flange, leaving a narrow space for the escape of the steam when the valve is opened, but which, although of greater diameter than the valve-seat, by reason of the said lap, presents a less area of opening for the escape of steam than is produced at the valve-seat, so that the steam which escapes through the area between the valve shall exert pressure against the said surrounding surface, and thereby not only open the valve completely, but hold it up until the pressure of the steam in the boiler falls below the pressure by which the valve was opened.

One part of my present invention relates to a means for regulating or adjusting the area of the aperture for the escape of the steam after acting on the said surface outside of the valve-seat, so that the valve may be set to close at any desired pressure below the pressure which will open; and this part of my invention consists in making the aperture or apertures for the escape of the steam, after it has acted on the said surface, outside of the valve-seat, adjustable.

My said invention also relates to means for preventing the guides and stem of a valve controlled by a spring from binding, and thereby impeding the movements of the valve; and this part of my said invention consists in making the pintle or stem, which receives the tension of the spring, bear on the valve so far below the plane of the

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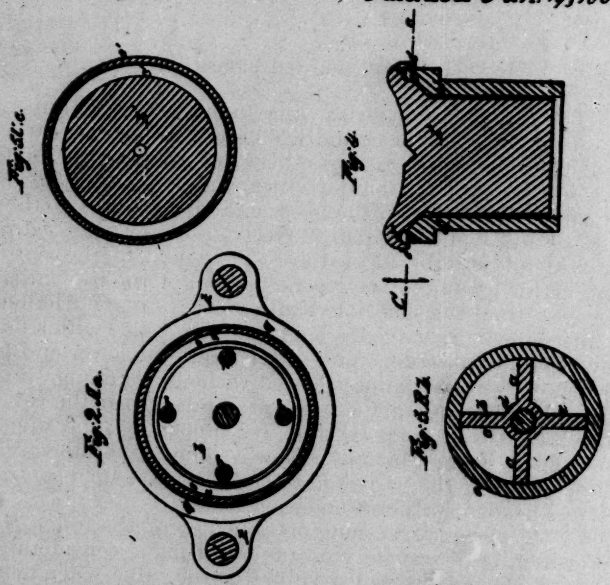
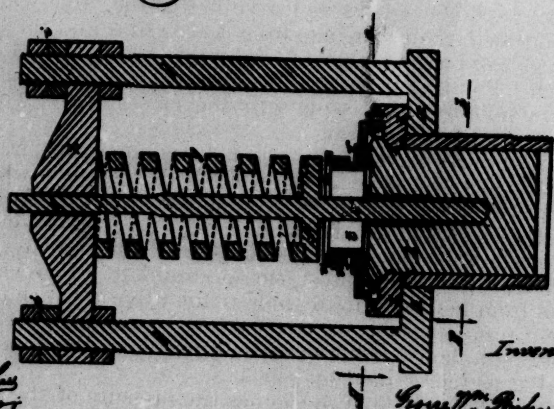
G. W. Richardson.

Safety Valve.

No. 85,903. Patented Jan. 19, 1864.





Witnesses:
J. J. Sullivan
H. C. Loor

Inventor:
George Wm. Richardson

valve-seat as that the force of the spring shall always be communicated to the valve in the direction of its axis.

I will first describe the preferred mode of application of my said invention, as represented in Figs. 1, 2, and 3 of the accompanying drawings.

In the said figures *a* represents the valve-seat, which is to be attached to a steam boiler or generator in the usual or any other suitable manner, and which is formed in the usual manner with a bevelled seat for the valve *b*, fitted thereto by what is well known as a "ground-joint."

(Here follows diagram marked page 138.)

The valve is formed with wings, *c*, in the usual manner,
139 & 140 properly fitted to the cylindrical bore of the valve seat to act as guides. It is cast or otherwise formed with an enlargement, *d*, at the junction of the wings, and extending down about one-third of the way from the lower end of the wings, so that a central hole may be drilled therein to receive a rod or stem, *e*, the lower end of which is suitably formed to rest as a pivot on the centre of the bottom of the said hole, so that no portion of the rod which is of less diameter than the said hole shall touch to make friction. A short distance above the valve the said rod, *e*, is formed with a flat and circular disc-like projection, *f*, on which bears the lower end of a helical spring, *g*, that surrounds the rod without touching; and this spring is held down to make the required pressure on the valve by a cross-head, *h*, held in place by nuts, *i*, *i*, tapped on the upper ends of two rods, *j*, *j*, from a plate, *k*, below a flange, *l*, of the valve-seat. The upper end of the valve-rod or stem, *e*, plays in a central hole in the cross-head, *h*, without touching.

By reason of the spring, *g*, bearing on the disc of the rod, *e*, the lower end of which bears centrally on the valve at a considerable distance below the bevelled seat, it results that the valve, when moving up and down, cannot deviate from a true line, and that neither of the wings can be made to chafe or bind in the bore of the valve-seat; and it follows, also, that the valve-rod, when once placed centrally in the hole in which it plays in the cross-head, *h*, will move up and down without touching.

It is well known that safety-valves, as heretofore made, frequently fail to open when the steam goes beyond the pressure to which it is loaded, because of undue friction and binding of the parts; and this is effectually prevented by the arrangement hereinabove described.

When used on locomotive boilers of coal-burning engines, or other places where ashes, smoke, dust, etc., accumulate, to prevent such impurities from getting into the hole in the valve in which the valve rod or stem rests, the said rod may be provided with a washer or a sleeve, having a flange at the upper end resting on the upper surface of the valve, as represented by Fig. 1.

It is desirable that so soon as the pressure of the steam in
141 the boiler or generator reaches the pressure at which it should be relieved, the safety valve should open wide for the free

escape of steam, and that the valve should remain open until the pressure in the boiler is reduced below the pressure by which the valve which opened, and that it should be so organized that the engineer may be able to adjust it so that it will close at any desired number of pounds' pressure below the pressure at which it was opened. To accomplish these results was the main object of my said invention.

To the upper surface of the valve I secure a cap-plate or annulus, *m*, formed with a downward-projecting flange, *n*, at its outer periphery, leaving an annular space, *o*, all around between the outer periphery of the valve and the inner periphery of the flange *n* of the said cap. And the upper surface of the valve seat *a* is extended all around, a little beyond the outer periphery of the flange *n* of the cap, leaving an annular surface, *p*, surrounded by an unward-projecting rim, *q*, the plane of the upper edge of which, when the valve is closed, extends a short distance above the plane of the lower edge of the flange *n* of the cap.

The said cap-plate *m* is connected with the top of the valve by studs *r*, *r*, or cast with it in such manner as to leave an open space, *s*, between the two for the passage of steam to the central aperture *t* in the cap, through which steam can escape when the valve is lifted from its seat. This central aperature is surrounded by a projecting cylindrical flange, threaded on the outside, to which is fitted a threaded ring, *u*, that can be turned up or down to any desired elevation, and there secured by a set-screw, *v*.

The disc-like projection *f* on the valve-rod or stem *e* extends over the said central aperture *t* in the cap-plate *m*, and at such an elevation that the upper edge of the adjustable ring can be set in contact with it, or let down so far below it as to leave sufficient space for the free escape of steam.

From the foregoing it will be seen that when the pressure of steam in the boiler or generator becomes sufficient to lift the valve from its seat, it acts against the surface of the annular space *o*, between the bevel of the valve seat and the downward-projecting flange
142 *n* of the cap, to assist in lifting and holding up the valve, particularly when the valve is borne down by the tension of a spring which presents an increasing resistance as the valve is lifted.

If the projecting rim *q* were in the same plane with the lower edge of the flange *n*, the diameter of these parts being greater than that of the valve-seat, on the lifting of the valve and cap the area of the opening between the flange *n* of the cap and the projecting rim *q* would be greater than the area of the opening between the valve and its seat, just in proportion as the diameter of the one is greater than the other, and the steam escaping from the valve would pass unchecked between the flange *n* and rim *q*, and would not exert any force against the surface of the annular space *o*; but as the rim *q* extends above the lower edge of the flange *n* of the cap-plate, it follows that the aperture between the valve and its seat, by the lifting of the valve, is always greater than the aperture between the

flange *n* and the rim *q*, and hence the escaping steam, by its elastic force, will act against the surface of the annular space *o*, to assist in lifting and holding up the valve until the pressure in the boiler or generator falls below the pressure by which the valve was firs opened.

The difference between the pressure against which the valve will close and the pressure by which it will be opened will depend upon the distance between the outer periphery of the flange *n* of the cap-plate and the inner periphery of the projecting rim *q*. To render this adjustable, the area of the aperture for the escape of steam beyond the valve-seat must be adjustable. This is effected by the raising or lowering of the ring *u*. If it be set to its lowest position the steam escaping from the valve will be free to escape between the top of the valve and the cap through the central aperture, and thence between the upper edge of the ring *u* and the disc *f* without materially aiding to lift or hold up the valve; but by setting the ring *u* nearer to the under surface of the disc *f*, and thereby reducing the space for the escape of steam, it will be caused to act by its elastic force against the annular space *o* of the cap-plate, and thus assist in lifting the valve and holding it up.

I have described and represented this as the simplest mode of adjusting the area of the aperture for the escape of the steam
143 after it passes the valve-seat; but it will be obvious that the same result may be attained by equivalent means, such, for instance, as making the ring *q* in adjustable segments, so that its diameter can be increased or diminished; but this would be more complicated than the mode first and fully described; and it will also be obvious that the devices for holding up the valve may be inverted, as represented in Figs. 4 and 5 of the accompanying drawings, in which a^1 is the valve-seat and b^1 the valve, with its bevelled ground-joint, the valve-seat a^1 having a flat annular surface, c^1, beyond the bevel, and the valve an annular surface, d^1, with a downward projecting flange, e^1, the lower edge of which, when the valve is closed, extends a little below the plane of the surface c^1 of the valve-seat, and a narrow annular space being left for the escape of steam between the inner periphery of the said flange and the outer periphery of the valve-seat a^1, as set forth in my patent of Sept. 25, 1866.

What I claim as new, and desire to secure by letters patent, is—

The combination of the surface beyond the seat of the safety-valve, with the means herein described for regulating or adjusting the area of the passage for the escape of steam, substantially as and for the purpose described.

GEORGE WM. RICHARDSON.

Witnesses:

I. I. TILLINGHAST.

W. H. POOR.

144 United States Patent Office.

ERASTUS B. KUNKLE, of Fort Wayne, Indiana, Assignee to Himself and E. BOSTICK, of same place.

Improvement in Lock-Up Safety Valves.

Specification forming a part of Letters Patent No. 162,831, dated May 4, 1875. Application filed November 14, 1874.

To all whom it may concern:

Be it known that I, Erastus B. Kunkle, of Fort Wayne, in the county of Allen and State of Indiana, have invented a new and improved lock-up safety valve, of which the following is a specification:

My invention is an improvement in the class of safety valves which are constructed with an annular chamber in the under side of a flange formed on the head thereof, the same being generally held to their seats by a rod, or stem, which enters a central recess, in the upper side of the valve.

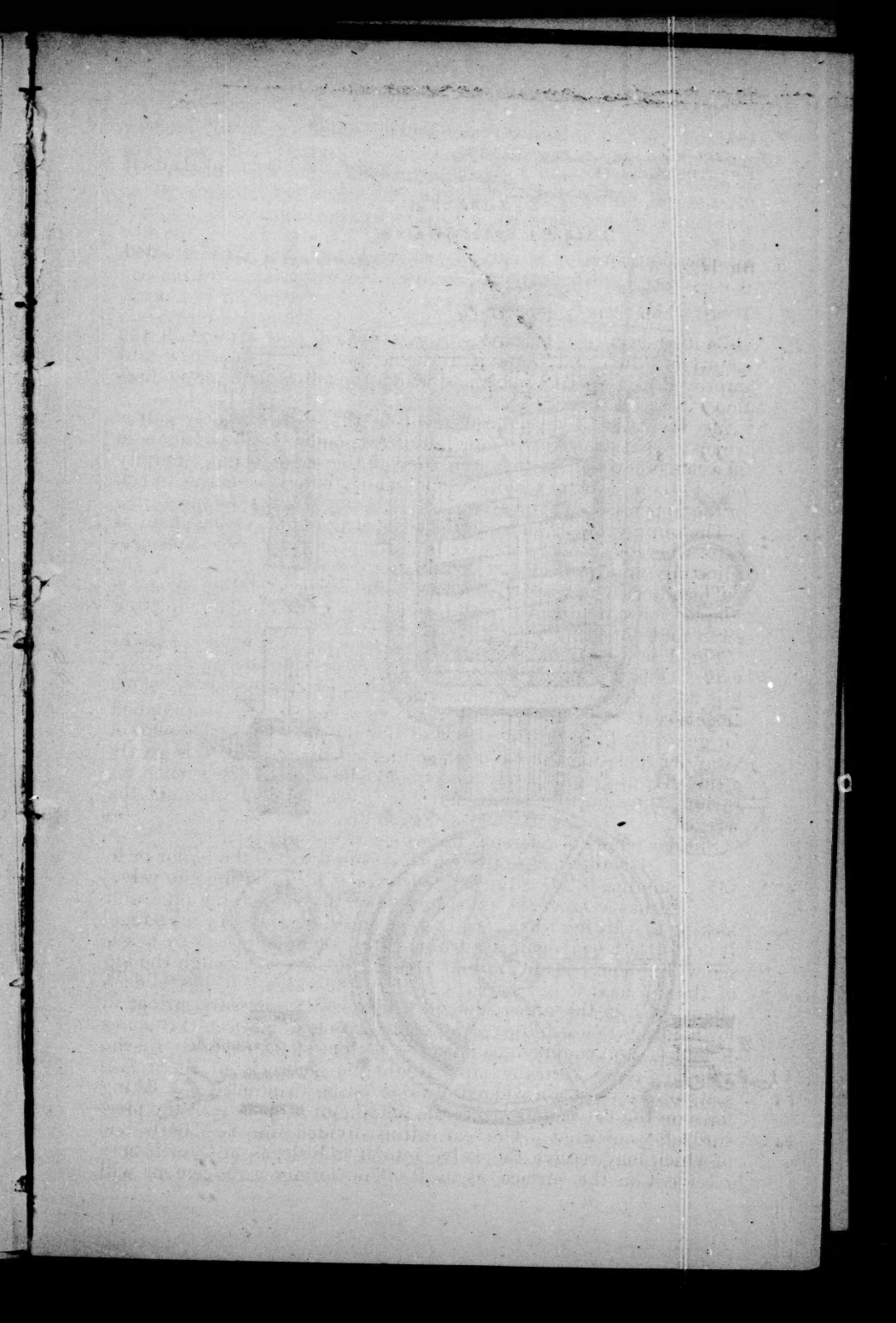
The improvement relates to the construction and arrangement of parts, whereby economy of space is attained, and the sealed pressure-adjusting screw protected, as hereinafter described.

The adjusting screw for regulating the tension of the spring is adapted for and provided with a split-wrench, with taper-adjusting screw and nut for turning it.

Fig. 1 is a sectional elevation of the improved lock-up safety valve. Fig. 2 is partly a top view and partly a horizontal section. Fig. 3 is a detail in section, showing a modified form of the valve and its seat. Fig. 4 is a detail in top view, showing the seal applied for guarding the adjusting screw of the spring. Fig. 5 is a plan of a cap for inclosing the top of the adjusting screw. Fig. 6 is partly a side elevation and partly a sectional elevation of the wrench for turning the adjusting screw, and Fig. 7 is an end elevation of the wrench.

Similar letters of reference indicate corresponding parts.

A is the steam-pipe, which is connected to the boilor or to
145 another B. C is the cap to this pipe, for inclosing the valve. It has a flange, D, extending down the side of the pipe, and locking to it by the ribs E on the pipe and the grooves in the flange. It is also fastened against turning after being adjusted by a set-screw, F. There is an annular escape passage, G, through the top of the cap next to the flange, C. H is the valve. It has a deep chamber, I, in the upper side, in which is the pressure-spring, J, for holding it closed, the spring being arranged between the plates K and L., and confined against the bottom of the chamber by the adjusting-screw M in the cap. N are the channels in the valve-seat, to receive steam when the valve opens to amplify the lifting force on the valve, and insure the holding of it open until the pressure falls somewhat. The seat is thus divided into two parts, one of which may receive the valve into it a little, as at Q, or it may receive it on the surface, as at R. The former arrangement will



No. 547. Consolidated Safety Valve Co. v. Kunkle. Page 146.

E. B. KUNKLE.

Lock-Up Safety-Valve.

No. 162,831. Patented May 4, 1875.

Fig. 1

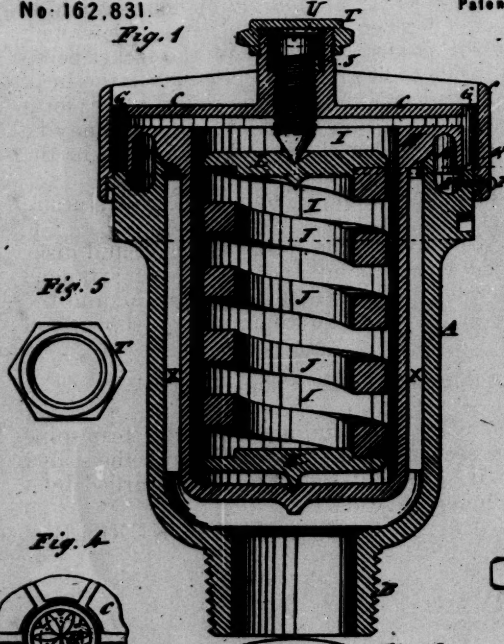


Fig. 3.

Fig. 5

Fig. 6

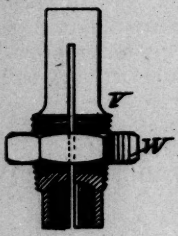


Fig. 4

Fig. 2

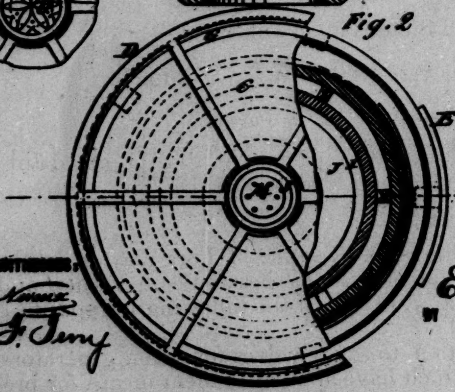


Fig. 7

WITNESSES:
C. Kunkle
A. F. Terry

INVENTOR:
E. B. Kunkle
BY
Munn & Co
ATTORNEYS.

probably be most efficient in retaining the steam in the chambers to increase the lift, but both will act in the same manner to a certain extent. The adjusting-screw M screws down into a socket, S, to be covered by a cap, T, and to guard against improperly changing it by unauthorized persons, a seal, consisting of a lead disc, *v*, is put on and fastened by pressing some parts into holes or recesses in the top of the screw, so as to hold it on temporarily to prevent the application of a wrench for turning it. The wrench consists of the taper split socket-key V and nut W, the socket being made round and ribbed inside to fit grooves to be made in the head of the screw, to prevent the wrench from slipping round. This form is also difficult to imitate by false keys, but other forms may be used. The valve has wings X to keep it in proper position in the steam-pipe.

Having thus described my invention, I claim as new and desire to secure by letters patent—

1. The cup or chambered valve H, the spiral spring J, and disks K L, respectively provided with a point and recess, and arranged within the valves, the pointed pressure-adjusting screw M, and the steam-pipe or casing A, having cap C, all combined as shown and described.

(Here follows diagram, marked page 146.)

2. In a safety valve, the combination of the steam-pipe
147&148 cap C, having a socket S, and screw-cap T, with the sealed pressure-screw M, to permit the latter to be turned by a wrench, substantially as herein described.

ERASTUS B. KUNKLE.

Witnesses:
E. N. THOMAS.
HENRY ZIMERMAN.

United States Patent Office.

ERASTUS B. KUNKLE, of Fort Wayne, Indiana.

Improvement in Safety Valves.

Specifications forming part of letters patent No. 193,411, dated July 24, 1877; application filed June 4, 1877.

To all whom it may concern:

Be it known that I, Erastus B. Kunkle, of Fort Wayne, in the county of Madison, and State of Indiana, have invented a new and improved lock-up safety valve, of which the following is a specification:

This invention has relation to safety valves for steam generators, and especially to valves which have applied to them means for preventing them from being tampered with by improper persons.

The invention will first be described in connection with the drawings, and then pointed out in the claims.

No. 5147- Consolidated Safety Valve Co. v. Kunkle. Page 146.

E. B. KUNKLE.

Lock-Up Safety-Valve.

No. 162,831. Patented May 4, 1875.

Fig. 1

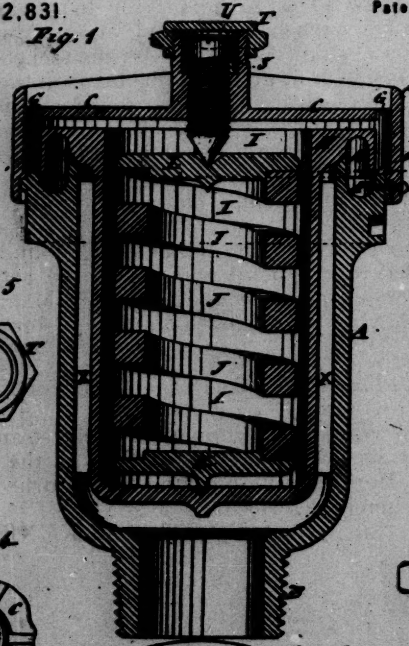


Fig. 3.

Fig. 5

Fig. 6

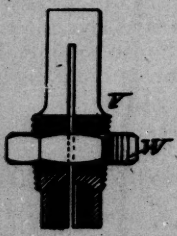


Fig. 4

Fig. 2

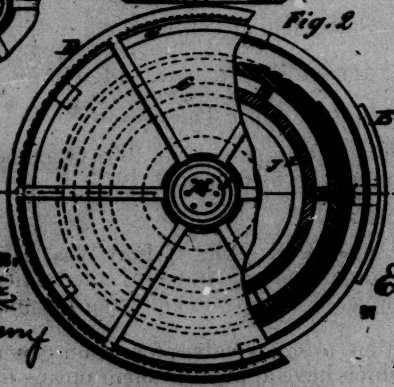


Fig. 7

WITNESSES:

E. Kunkle

A. F. Jemy

INVENTOR:

E. B. Kunkle

by Munn & Co

ATTORNEYS.

probably be most efficient in retaining the steam in the chambers to increase the lift, but both will act in the same manner to a certain extent. The adjusting-screw M screws down into a socket, S, to be covered by a cap, T, and to guard against improperly changing it by unauthorized persons, a seal, consisting of a lead disc, *v*, is put on and fastened by pressing some parts into holes or recesses in the top of the screw, so as to hold it on temporarily to prevent the application of a wrench for turning it. The wrench consists of the taper split socket-key V and nut W, the socket being made round and ribbed inside to fit grooves to be made in the head of the screw, to prevent the wrench from slipping round. This form is also difficult to imitate by false keys, but other forms may be used. The valve has wings X to keep it in proper position in the steam-pipe.

Having thus described my invention, I claim as new and desire to secure by letters patent—

1. The cup or chambered valve H, the spiral spring J, and disks K L, respectively provided with a point and recess, and arranged within the valves, the pointed pressure-adjusting screw M, and the steam-pipe or casing A, having cap C, all combined as shown and described.

(Here follows diagram, marked page 146.)

2. In a safety valve, the combination of the steam-pipe
147&148 cap C, having a socket S, and screw-cap T, with the sealed pressure-screw M, to permit the latter to be turned by a wrench, substantially as herein described.

ERASTUS B. KUNKLE.

Witnesses:
E. N. THOMAS.
HENRY ZIMERMAN.

United States Patent Office.

ERASTUS B. KUNKLE, of Fort Wayne, Indiana.

Improvement in Safety Valves.

Specifications forming part of letters patent No. 193,411, dated July 24, 1877; application filed June 4, 1877.

To all whom it may concern:

Be it known that I, Erastus B. Kunkle, of Fort Wayne, in the county of Madison, and State of Indiana, have invented a new and improved lock-up safety valve, of which the following is a specification:

This invention has relation to safety valves for steam generators, and especially to valves which have applied to them means for preventing them from being tampered with by improper persons.

The invention will first be described in connection with the drawings, and then pointed out in the claims.

In the annexed drawings Figure 1 is a diametrical section through my improved valve. Fig. 2 is a top view of the valve cap reduced in diameter. Fig. 3 is a horizontal section, showing the spring-catch, spring, and spring chamber, and the ribs or feathers. Fig. 4 shows, in section, the key for adjusting the force of the spring on the valve.

Similar letters of reference indicate corresponding parts.

The letter A designates the tubular box or body of the instrument, which is enlarged above and contracted below, and constructed with a male thread, cut on its lower end, and a
149 number of holes in its largest end, to receive a spanner for screwing it into place on a boiler. A screw thread is also cut on the upper end of the body A, to receive a perforated cap, B, which is held fast by a small set screw (shown in Fig. 1). In the centre of the cap B is a tubular hub, *b*, which is screw-tapped inside part of its length, and tapered outside, below the top of the cap. Above the interior threaded portion of the hub *b* is a chamber, into which a nut, b^1, is applied, receiving inside of it a screw, b^2.

C is a cone-pointed screw, which is screwed into the hub *b*, so as to bear centrally on a flanged cup, *a*. This screw C is grooved to receive the feather *c*, on the inside of the barrel of a key, C^1, by means of which key and a lever the screw can be turned, and a helical spring, D, compressed more or less, as may be required. After this adjustment, a soft metal cap or seal is stamped upon the perforated head of the screw C, and the latter locked by means of jam-nut described.

The top of the cover B is slotted, as shown at *e e*, for the escape of steam during an alarm, and concentrically cast on the bottom of the cover is an annular flange, *f*, which laps over the largest part or upper end of the valve G, and shuts off communication between the interior of the cap B and the long spring chamber of the valve. I thus exclude everything injurious from the spring chamber. The interior of the cylindrical wall of the cap B is constructed with a raised rib or seat, *i*, against which the periphery of a regulator, E, is closely fitted, as shown in Fig. 1.

The valve G is composed of a flanged portion or head, *h*, surrounding the upper end of a cylindrical elongated cup, adapted to contain the spring D, which is compressed between the flange of cup *a* and a foot, a^1, stepped on the bottom of the valve. The head *h* of the valve G is constructed with an annular bevel, 2, a small annular recess, 3, and a large annular recess, 4, in its bottom side, which recess forms, in combination with the upper concave and stepped surface of the regulator E, a serpentine port, *s*, for the passage of the steam from the body A to the exit slots *e e* through cap B, as indicated by the course of the arrows in Fig. 1.

(Here follows diagram, marked page 150.)

The steam first escapes between the bevelled portion 2 of
151&152 the valve and a corresponding bevelled seat formed on a flange, *j*, cast on the body A. It then takes the course

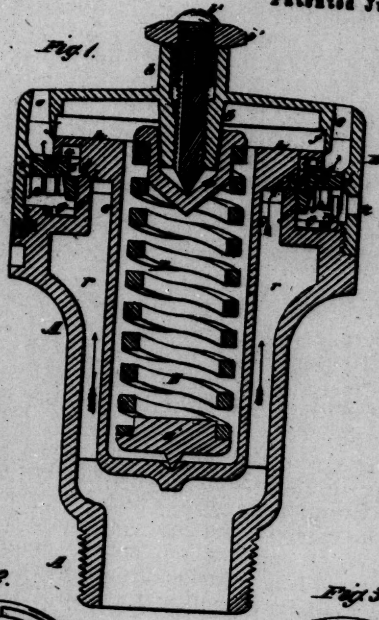
E. B. KUNKLE.

SAFETY-VALVE.

No. 193,411.

Patented July 24, 1877.

Fig. 1.



No. 547
Consolidated Safety
Valve Co. v. Kunkle
Page 150.

Fig. 2.

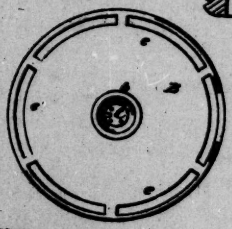
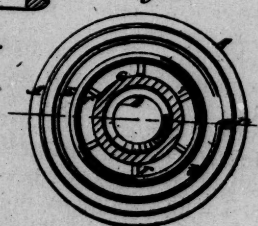


Fig. 4.

Fig. 3.



WITNESSES:

Francis M. Carter

J. H. Scarborough

INVENTOR:

E. B. Kunkle

BY Munn & Co

ATTORNEYS.

indicated, being prevented from "blowing back" by the peculiar hape of the port.

The regulator E is a ring, which is screwed on the outside of the flange *j*, and constructed with an annular concavity and a step, as above stated. Teeth *p*, or their equivalents, are formed around the bottom of the regulator, and an oblong hole, *k*, is made through the skirting of the cap B, by which a rod can be used for turning the regulator about its vertical axis, and thus adjusting it higher or lower on the flange *j*, increasing or diminishing the capacity of the outlet port *s*.

The regulator E is held fast after it is properly adjusted by means of a lip, *n*, which is formed on a spring, *t*, and which engages with the teeth *p*. By pressing the lip *n* inward the regulator will be disengaged from it, and may be adjusted as described.

It will be seen from the above description that the steam passing up between the ribs *r*, cast either on the body A or valve-cup, operates on the valve-flange *h* to lift the valve from its seat and enlarge the port *s*, thereby compressing the spring D, which reacts to shut the valve when the steam in the boiler is reduced to a given or predetermined pressure.

Having thus described my invention, I claim as new, and desire to secure by letters patent—

1. In combination with the valve G, acted on by a spring and adjusting-screw, C, as set forth, the valve-head *h*, constructed with a bevelled surface, 2, and annular channels, 3, 4, forming, in connection with the flange *j* and regulator E, a port, *s*, substantially as described.

2. The regulator E, provided with teeth and working in connection with a catch, *n*, as and for the purpose specified.

ERASTUS B. KUNKLE.

Witnesses:
JOHN BOSTICK.
EDWARD LANNAN.

153 *Kunkle's File Wrapper, etc.*

Assigned to self and E. Bostick.

Petition.

To the Commissioner of Patents of the United States of America:

The petition of Erastus B. Kunkle, of Fort Wayne, in the county of Allen and State of Indiana, respectfully represents—

That your petitioner has invented a new and improved lock-up safety valve, which he verily believes has not been known or used prior to the invention thereof by your petitioner. He, therefore, prays that letters patent of the United States of America may be granted to him and his legal representatives the exclusive right to the same upon the terms and conditions expressed in the act of Congress in that case made and provided, he having paid fifteen dollars into the Treasury of the United States, and otherwise complied with the requirements of said act. And he hereby authorizes D. D. Munn

and A. E. Beach, of the firm of Munn & Co., of the cities of New York and Washington, or their accredited agents, to act as his attorneys in presenting the application, and in making all such alterations and amendments as may be required, and to sign his name to the drawings.

ERASTUS B. KUNKLE.

Oath.

COUNTY OF PORTER, } ss:
State of Indiana, }

On this 4th day of November, 1874, before the subscriber, a notary public in and for said county, personally appeared the above-named Erastus B. Kunkle, and made solemn oath that he verily believes himself to be the original and first inventor of the within-described improved lock-up safety valve, and that he does not know or believe that the same was ever before known or used; and that he is a citizen of the United States.

[L. S.] HENRY ZIMERMAN,
Notary Public.

154 *Specification Describing a New and Improved Lock-up Safety Valve, invented by Erastus B. Kunkle, of Fort Wayne, in the County of Allen, and State of Indiana.*

Erase and insert "C," April 17, 1875.

In this improvement the valve is secured under a cap fastened on the top of the steam pipe, and it has a chamber in the upper side in which is a strong spring for holding it closed, the spring bearing at the upper end against an adjusting screw in the cap for varying the tension.

The screw extends up through the cap, to be turned by a wrench for adjusting it, and has a seal, to guard against being shifted unadvisedly.

Erase as per Jan. 4, 1874.

There is a chamber in the valve and its seat for exposing a larger area to the lift of the steam when the valve rises, to ensure the keeping of the valve open till the pressure falls to the safety-point.

The adjusting screw for regulating the tension of the spring is adapted for and provided with a split wrench, with taper adjusting screw, and nut for turning it.

Figure 1 is a sectional elevation of the improved lock-up safety valve.

Figure 2 is partly a top view and partly a horizontal section.

Figure 3 is a detail in section, showing a modified form of the valve and its seat.

Figure 4 is a detail in top view, showing the seal applied for guarding the adjusting screw of the spring.

Figure 5 is a plan of a cap for inclosing the top of the adjusting screw.

Figure 6 is partly a side elevation and partly a sectional elevation of the wrench for turning the adjusting screw, and

Figure 7 is an end elevation of the wrench.

Similar letters of reference indicate corresponding parts.

155 A is the steam-pipe, which is connected with the boiler, or to another pipe, at B.

C is the cap to this pipe for enclosing the valve; it has a flange, D, extending down the side of the pipe, and locking to it by the ribs E on the pipe and the grooves in the flange; it is also fastened against turning, after being adjusted, by a set screw, F. There is an annular escape passage, G, through the top of the cap next to the flange C.

H is the valve; it has a deep chamber I in the upper side, in which is the pressure-spring J for holding it closed, the spring being arranged between the plates K and L, and confined against the bottom of the chamber by the adjusting screw M in the cap.

N is the channels in the valve-seat to receive steam when the valve opens to amplify the lifting force on the valve, and insure the holding of it open until the pressure falls somewhat. The seat is thus divided into two parts, one of which may receive the valve into it a little, as at Q, or it may receive it on the surface, as at R. The former arrangement will probably be most efficient in retaining the steam in the chambers to increase the lift; but both will act in the same manner to a certain extent.

The adjusting screw, M, screws down into a socket, S, to be covered by a cap, T, and to guard against improperly changing it by unauthorized persons, a seal, consisfing of a lead disc, V, is put on and fastened by pressing some parts into holes or recesses in the top of the screw, so as to hold it on temporarily to prevent the application of a wrench for turning it.

The wrench consists of the taper-split socket key V, and nut W, the socket being made round, and ribbed inside to fit grooves to be made in the head of the screw to prevent the wrench from slipping round. This form is also difficult to imitate by false keys; but other forms may be used. The valve has wings, X, to keep it in proper position in the steam pipe.

Having thus described my invention, I claim as new, and desire to secure by letters patent—

156

Erase and Insert "A" Jan. 4, 1876.

The combination of the chambered valve H, spring J, discs K, L, pressure screw M and pipe A, substantially as specified.

The socket S, cap T, and seal V, combined with the screw M, substantially as specified.

The valve and valve-seat chambered at N, in the manner and for the purpose described.

ERASTUS B. KUNKLE.

Witnesses:
E. N. THOMAS,
HENRY ZIMERMAN.

(No. 1.)
M. E. C.

EXAMINER'S ROOM, No. 19,
U. S. PATENT OFFICE,
WASHINGTON, D. C., *Nov.* 30, 1874.

ERASTUS B. KUNKLE, *Care Munn & Co, Washington, D. C.:*

Lock-up safety-valve, filed Nov. 14, 1874.

The first claim is substantially anticipated by patents to F. Rachow, Sept. 28, 1869, No. 95382, div. safety valve; the second by rejected application of E. B. Kunkle, filed Oct. 3, 1870, div. safety valve; the third by patent to George W. Richardson, Sept. 25, 1866, No. 58294, and William Naylor reissue, Nov. 9, 1869, No. 58962, same div., and are accordingly rejected.

D. K. HOLSTON, *Ass't in Charge.*

O. E. DUFFY, *Ass't.*

WASHINGTON, D. C., *January* 2*d*, 1875.

Hon. J. M. THACHER, *Comm'r of Patents.*

SIR: I hereby amend the specification in my application for letters patent for lock-up safety valve, filed November 14th, 1874, as follows:

157 Erase the paragraph of the statement of invention, commencing with the word "there," on the 3d line from bottom of page 1, and ending with the word "point," on the 6th line of page 2.

Erase claims and insert:

Erase and Insert B, Jan. 14, 1875. A.

~~1st. The combination of the chambered or hollow valve H, enclosed spring J, and discs K L, with the steam pipe or surrounding casing A, cap C, and pressure screw M, substantially as herein shown and described for the purpose specified.~~

2d. In a safety valve, the combination of the steam-pipe cap C, having a socket S and screw cap T, with the sealed pressure screw M, to permit the latter to be turned by a wrench substantially as herein described.

E. B. KUNKLE,
Per MUNN & CO.,
Attorneys.

(No. 1.)
C. L. A.

EXAMINER'S ROOM, No. 19,
U. S. PATENT OFFICE,
WASHINGTON, D. C., *Jan.* 7, 1875.

ERASTUS B. KUNKLE, *care Munn & Co., Washington, D. C.:*

Lock-up safety valve, filed Nov. 14, 1874.

Amendment filed Jan 4, 1875, has been considered.

The first claim is substantially anticipated by rej. application of P. Prosser, filed March 11, 1868, div. safety valves. If the second

claim be amended so as to avoid the old case of Kunkle, it might be favorably considered. See amendment above cited.

The first claim is rejected, and the second objected to.

H. A. SEYMOUR, *Examiner.*

O. E. DUFFY, *Ass't.*

158 WASHINGTON, *January* 11*th.*

HON. J. M. THACHER, *Comm'r of Patents.*

SIR: I hereby amend the specification in my application for letters patent for lock-up safety valve, filed November 14th, 1874, by erasing 1st claim and inserting:

Erase and insert "D," April 17, 1875. B.

~~1st. The combination of the valve H, having a chamber for the reception of a pressure-spring J, and provided with a horizontal valve-rim at its upper end with the chamber or steam pipe A, having a valve seat at its top, all constructed and arranged substantially as herein described.~~

E. B. KUNKLE,
Per MUNN & CO.,
Attorneys.

(No. 1.)
C. T. A.

EXAMINER'S ROOM, No. 19,
U. S. PATENT OFFICE,
WASHINGTON, D. C., *January* 15, 1875.

E. B. KUNKLE, *Care Munn & Co., Washington, D. C.*:

Lock-up safety valve, filed Nov. 14, 1874.

Amended claim filed January 14, 1875, has been considered.

Figures 822, 823, and 824, page 286, by N. P. Burgh, London, boilers and boiler-making, are held to anticipate said claim, and is accordingly rejected.

H. A. SEYMOUR, *Examiner.*

O. E. DUFFY, *Ass't.*

WASHINGTON, D. C, *April* 16, 1875.

Hon. J. M. THACHER, *Commissioner of Patents.*

SIR: I hereby amend the specification in my application for letters patent for lock-up safety valves, filed November 14, 1874, as follows:

159 Cancel all of recital of invention, and insert:

C.

"My invention is an improvement in the class of safety valves which are constructed with an annular chamber in the under side of a flange, formed on the head thereof, the same being generally held to their seats by a rod or stem which enters a central recess in the upper side of the valve.

"The improvement relates to the construction and arrangement of parts whereby economy of space is obtained, and the sealed pressure adjusting screw protected, as hereafter described."

Cancel clause of claim, and insert:

D. 1st. The cup or chambered valve H, the spiral spring J, and discs K L, respectively provided with a point and recess, and arranged within the valve, the pointed pressure adjusting screw M, and the steam pipe or casing A, having cap C, all combined as shown and described.

E. B. KUNKLE.
Per ——— ———,
Attorneys.

1874. $\frac{6\,7}{2\,4}$

DIV. 18. SEYMOUR.
No. 162,831. 42.

Erastus B. Kunkle, assignor to self and E. Bostick, of same place, of Fort Wayne, county of Allen, State of Indiana.

Lock-Up Safety Valve.

Received, November 14, 1874.
Petition, " " "
Affidavit, " " "
Specification, November 14, 1874.
160 Drawing, " " "
Model, " " "
Cert. dep.
1 cash, $15.00, " 12, "
Additional fee cert.
1 " " cash, $20.00, May 1, 1875.

Examined April 20, 1875, Seymour; 2 issue, April 20, 1875, Grinnell; 4 patented May 4, 1875; recorded, vol. —, page —; circular, April 21, 1875.
Munn & Co. prosent.

1874.

Contents.

Application for papers:
1. Rej. November 30, 1874.
2. Amendment "A," January 4, 1874.
3 Rej'd " 7, 1875.
4. Amendment "B," " 14, 1875.
5. Rej. " 15, 1875.
6. Amendment "C," "D," April 16, 1875.

Title.

Ex. M. McK. Improvement in lock-up safety valves.
J. A. W.

161, 162, 163, 164 *Affidavit of George W. Richardson.*

United States Circuit Court, Southern District of Illinois.

THE CONSOLIDATED SAFETY VALVE CO. *vs.* ERASTUS P. KUNKLE.

I, George W. Richardson, being duly sworn, on oath depose and say:

That I am 52 years of age; reside in Boston, Massachusetts, and am the superintendent of the Consolidated Safety Valve Company, complainants in this suit.

I was the patentee of the safety valve patented September 25, 1866, and also of the safety valve patented January 19, 1869; and I verily believe that I was and am the original and first inventor of both of the safety valves described in these two patents.

Before the year 1866 I had been engaged in the machine business for more than twenty years, and, during this period, mostly in connection with steam-engines. From 1858 to 1866 I was in charge of the Troy & Boston Railroad Repair Shops, and occasionally ran locomotives upon the said railroad.

I directed my attention to improving the safety valves in
165 use very shortly after I became acquainted with the construction and working of the steam engine, and my attention for more than twelve years before 1866 was directed to the action of the safety valves in use.

Coal-burning locomotives were being rapidly introduced during this time; and because of the fact that on closing the throttle valve, or shutting off the blower, the coal fire continues to generate steam with nearly the same rapidity, while a wood fire on each of such occasions at once moderates somewhat, additional precautions were necessary to prevent excessive pressure in the boilers. Many boiler explosions, and especially leaks, occurred from the strain of overpressure resulting from this cause.

This caused a great demand for an improved safety valve which should automatically and promptly relieve the boiler, while it should not practically disturb its working pressure; and there was, to my knowledge, no safety valve in the market, and I never heard of a single safety valve anywhere that would accomplish the result of relieving the boiler from excessive pressure with but a small loss of pressure, until I introduced my valve in the year 1866.

It immediately went into use, largely upon the railroads, and has continued in use largely until the present day, the use extending from locomotives to steamboats and to stationary and portable boilers; and it was not until the valve had been extensively introduced that there was any attempt at competition, and the only attempts at competition in this country have been from valves patented since 1866.

I verily believe, and I know of no fact to the contrary, that prior to the invention disclosed in the 1866 patent, no person had suspected that the action of a spring safety valve could be controlled by altering the size of the stricture or narrow passage through
166 which the steam escaped into the air, in combination with a

chamber to receive the escaping steam on its way from the ground joint of the valve to the atmosphere, under a surface extended from the head of the valve, thus enlarging its lifting area, and controlling the pressure under it.

I have read with great care the English patents referred to in this case, viz., those to Naylor, Beyer, Hartley, Green, Ritchie, and Webster. I have caused to be constructed and tried valves conforming to the specification and drawings of these patents as accurately as mechanical skill could make them, and I never found one of them that would work with a reduction of pressure less than twenty per cent., and most of them exceeded that percentage to as high as forty-five per cent. No one of these patents ever came to my knowlege until after my invention and introduction into use of my valve of 1866, or until after I had introduced into practical service at least 1,000 of my valves on locomotives.

No one of these valves is proportioned or arranged in such a way as to get the useful effect of my discovery, viz., the proportioning and operation of the stricture in the working of the valve; and certainly no one of the patentees, to judge from his description and illustration of his invention, so much as suspected that there was any practical and necessary relation between the stricture and the other working part of the valve organization, viz., the area of the valve, extended surface chamber, and spring or stricture.

This relation, in practice, I have found to be absolutely necessary in any safety-valve which has an extended surface chamber.

In my patent of 1869 I described a way of modifying the stricture by the use of an adjustable screw sleeve applied to an
167 orifice through which steam escaped, and I verily believe that I was and am the original and true inventor thereof; and this adjustable screw sleeve I had applied directly upon the edge of the valve as early as 1867. This gave to the user of the valve an opportunity of modifying its action by adjustment of the movable part in its organization, and without calling in the assistance of a mechanic with his tools, or sending the valve to a shop, or blowing off the steam of the engine; and this application of the adjustable screw sleeve to control the escape of steam and regulate the action of the stricture was, I verily believe, absolutely new at that time, and I have seen no reason, since 1869, to modify in any degree this belief.

There have been introduced and put in use in the United States since the patent of 1866 from 50,000 to 60,000 valves made under the authority of my patent, either by myself or by licensees and infringers who have paid me damages, and about one-third of these have had the adjustable stricture of my patent of 1869.

I have seen the Kunkle valves A & B, in evidence in this case, tried upon a boiler, and have examined their construction and method of work. They both of them embody the construction and mode of operation invented by me, and described in my patent of 1866, and the larger valve has the means of adjusting the stricture with a screw ring or a sleeve, described in my patent of 1869, and they work upon a boiler in the same way.

(Signed) GEO. W. RICHARDSON.

UNITED STATES OF AMERICA, *State & District of Massachusetts:*

BOSTON, *January* 2, 1881.

Personally appeared Geo. W. Richardson, who, being duly sworn, on oath deposes and says: He has read the foregoing affidavit, and subscribed the same, and the same is true, except the matters therein stated on information and belief, and those he believes to be true.

Before me.

[SEAL.] F. F. RAYMOND, 2ND,
Notary Publci.

168 *Affidavit of Charles A. Moore.*

United States Circuit Court, Eastern District of Illinois.

THE CONSOLIDATED SAFETY VALVE CO.
vs.
ERASTUS B. KUNKLE.

I, CHARLES A. MOORE, being duly sworn, on oath depose and say: That I am thirty-five years of age; at present reside in Lynn, Massachusetts, and am president of the Consolidated Safety Valve Company. And I further say that on or about the sixth day of June, A. D. 1879, I ordered from Erastus B. Kunkle in person, at Fort Wayne, Indiana, a safety-valve, such as he was then manufacturing, and desired him to send it to the Consolidated Safety Valve Company, at Boston, Massachusetts. In response to this order I received the safety valve which is filed in this case as "Kunkle Exhibit B," a drawing of which faces page 16 of Mr. Forbes' affidavit. A bill was sent at the same time with this valve, a copy of which is annexed hereto, and the original handed to counsel.

169 (Copy.)

FORT WAYNE, IND., *June 6th*, 1879.

Consolidated Safety Valve Co. bought of E. B. Kunkle.

June 6. To 1 2¼ in. safety valve ---------- $25 00

I further say that I submitted the said valve, Exhibit B, to the examination of our expert and counsel, and in consequence of information received from them, notified Mr. Kunkle, subsequently, as I had before, that said valve was an infringement of the Richardson patent.

At the time I ordered the said valves sent, I saw in the shop and office of said Kunkle a considerable number of valves of similar appearance exposed for sale, and in connection with said Kunkle examined and discussed the same, taking one or more of them to pieces in his presence, and pointing out to him the fact of the infringement of the Richardson patents as I then understood them.

And I further say that the said valves so examined by me at that time differed in no material respect from the valve, Kunkle Exhibit B, illustrated in the drawing opposite page 16 of Mr. Forbes' affi-

davit, and I recognize no difference except in the size of parts proportionate to the size of the valves between the valve represented in said drawing and the valves inspected by me at Mr. Kunkle's, and in the valves of the same size. I believe the parts, proportions, sizes and details were as near like the drawing referred to in the valves I saw at Mr. Kunkle's shop exposed for sale as it would be possible to make them with good manufacturing appliances.

170 I also have seen very many valves like the valves Exhibits A and B in possession of manufacturers of engines, &c., which I was informed came from Kunkle, and were marked with the same inscription as the valves A and B in this case; and I have seen a valve like Exhibit C^2 in this case, sent me by express, I know not from what source, marked as stated on the drawing; and I have had the same drawn, and submitted the same for test to Mr. Forbes. Among the manufacturers I refer to are the Mansfield Machine Works, of Mansfield, Ohio; Aultman & Taylor Company, of Mansfield, Ohio; Messrs. C. & G. Cooper & Company, of Mount Vernon, Ohio; Messrs. C. Aultman & Co., of Canton, Ohio; Pittsburg and Fort Wayne Railroad Company, at Pittsburg, Pennsylvania; Messrs. M. & J. Rumby, of Laporte, Indiana, and Messrs. H. T. Lally & Company, of Chicago, Illinois.

At the time I ordered valve Exhibit B, in June, 1879, I had a long conversation with Mr. Kunkle, and agreed to, and did, send him an expert's opinion on the valves he was then making like Exhibit B, which I ordered from him, and I saw him in Chicago in October last, and discussed the infringement, and I told him I must sue him unless he stopped the infringement; and he told me to sue him and have the thing settled, which I did, on behalf of my company, forthwith.

CHAS. A. MOORE.

171 UNITED STATES OF AMERICA, *State District of Massachusetts:* SUFFOLK, *ss:*

BOSTON, *Jan.* 11, 1881.

Personally appeared Charles A. Moore, who being duly sworn, on oath deposes and says he has read the foregoing affidavit, and subscribed the same, and the same is true, except the matters therein stated on information, and those he believes to be true.

Before me—

[SEAL.] F. F. RAYMOND, 2D,
Notary Public.

172 *Second Affidavid of Charles W. Forbes.*

Circuit Court of the United States, Southern District of Illinois.

THE CONSOLIDATED SAFETY VALVE COMPANY
vs
ERASTUS B. KUNKLE.

I, Charles W. Forbes, being duly sworn, on oath depose and say: That I am the same person who has formerly made an affidavit

in this cause. I have examined a valve submitted to me by Charles A. Moore as the one referred to in his affidavit, as a valve recently received by him, which valve is represented in cross-section in the drawing, "Complainant's Exhibit Kunkle C², " and it contains stamped upon the belt forming the edge of the fillet around the body of the valve-casing, above the curved line near the part A, the words and figures inscribed at the bottom of said drawing.

I have caused the parts represented in this drawing "Kunkle C²" to be lettered, to correspond to the lettering of the drawing of letters patent to said Kunkle, dated July 24, 1877, which patent drawing faces page 68 of the printed affidavit, an exhibit heretofore offered by me in this case.

The sectional dawing "Exhibit Kunkle C²," is an accurate drawing in all its parts from the valve submitted to me, and is of the same size.

This valve is made substantially like, in all material respects, to the valve shown in "Complainant's Exhibit Drawing Kunkle
173 B," which faces page 16 of my former affidavit, and it is varied in construction simply in three respects.

One of these is, that the upper face of the screw-ring, marked E in the drawing "Kunkle C²," is flat in the valve from which this drawing was made, while the corresponding face in the valve represented in drawing "Kunkle B," is slightly concave.

Another respect is that the flange lettered *h* in the drawing "Kunkle C²," is plain in the valve represented in that drawing, while in the valve represented in drawing "Kunkle B" it has a slight downward projection at its periphery, which downward projection or flange is about one-eighth of an inch wide and about one-fiftieth of an inch deep.

These two differences in no way change the operation of the valve.

The third difference is, that the flange *h* on the valve represented in "Kunkle C²," does not fit closely the surrounding depending flange *f*, on the cap, as it does in the valve represented in "Kunkle B;" but there is an annular space between the two flanges about one one-hundredth of an inch wide, and, in my opinion, this annular space does slightly affect the operation of the valve when the adjustable ring is more widely opened than desirable for the best operation of the valve.

This I consider to be an accident of the manufacture. There is also on the valve represented in "Exhibit Kunkle C²," a lifting lever, marked Q. working upon a vertical rod, marked X in the drawing, which lever and rod serve to lift the valve at times when the steam pressure is insufficient; but this is a mere addition.

I submitted this valve to trials upon a steam boiler with eighty pounds pressure to the inch, with two different springs, one of them of a compression of four-tenths of an inch, to hold eighty pounds to the inch; and the other of a compression of one-fourth of an inch, to hold the same pressure. These springs are respectively a comparatively weak spring, and a spring of moderate strength for a valve of this size, at this pressure. The weak spring of four-tenths of an inch compression was the one which came with the valve,

and the stronger spring was applied to demonstrate the value
174 and necessity of the adjustable stricture made by the screw-ring in the proper adjustment and working of the valve, as in the experiments already testified to; and to show what the function of the screw-ring is in said valve, and how its adjustment influences the operation of the valve under different adjustments and conditions, and to determine the relation of stricture and spring to each other under these different adjustments and conditions.

The following table of dimensions, &c., of the valve represented in the drawing "Kunkle C²," includes corresponding measurements to those given on page 16 of my former affidavit:

1.	Diameter of steam-way	1.5″
2.	Area or initial surface exposed to the steam-way	1.76″
3.	Total area of valve and extended flange	3.87″
4.	Supplemental area (difference of above areas)	2.11″
5.	Circumference of extended flange	6.97″
6.	Compression of strong spring under 80 pounds pressure to the square inch	.25″
7.	Compression of weak spring under 80 pounds pressure to square inch	.4
8.	Comparative areas of initial and supplemental surface in valve represented in "Kunkle Drawing, Exhibit C²," 1.76 : 2.11	5 : 6
9.	Comparative areas of initial and supplemental surface in valve represented in Richardson patent drawing of 1866, 1.4 : 1.617	5 : 5.77
10.	Vertical distance of depending flange *f* on cap of valve casing from under surface of extended flange *h*, valve-seated ("Kunkle C²") effective lift of valve	.06
11.	No. of screw-threads per inch on adjustable ring E	18
12.	No. of circumferential notches in periphery of ring	29
13.	Amount of vertical adjustment of ring to rotation of same, one notch (less than $\frac{1}{100}$ of an inch)	.0192′
14.	Area of stricture, ring adjusted 4 notches open, valve closed	.54″
15.	Same, valve open wide	.6″
175 16.	Same, 6 notches open, valve closed	.8″
17.	Same, valve open wide	.86″
18.	Same, 8 notches open, valve closed	1.″06
19.	" 8 " " " open wide	1.″12
20.	" 10 " " " closed	1.″34
21.	" 10 " " " open wide	1.″4
22.	" 11 " " " closed	1.46
23.	" 11 " " " open wide	1.52
24.	" 12 " " " valve closed	1.6
25.	" 12 " " " open wide	1.66
26.	Area of escape opening through top of case	1.42

I tried this valve, shown in the drawing "Kunkle C², " with both springs, and the following were the results of the trial:

No. of experiments.	No. of notches open.	Valved opened at lbs.	Valve closed at lbs.	Loss of pressure—lbs.	Initial compression of spring.	Effective lift—inches.
1	4	80	69	11	.4	.06
2	6	80	72	8	.4	.06
3	8	80	74	6	.4	.06
4	10	80	75.5	4.5	.4	.06
5	12	80	76.5	3.5	.4	.06
6*	4	80	72	8	.25	.06
7	6	80	74	6	.25	.06
8	8	80	76.5	3.5	.25	.06
9	10	80	77	3	.25	.06

*Here the spring was changed and a stronger one applied.

The action of the valve in each of this series of experiments was prompt and decisive; but beyond the extreme adjustments indicated, viz, twelve notches open with the weak spring and ten notches open with the strong spring, the valve ceased to pop and became erratic in its action. This, in a measure, was due to the fact that the escape opening in this case was of less area than the stricture at the
176 edge of the valve, causing the steam to be huddled between the edge of the valve and the opening in the case, and thus to enter the passage left between the depending flange *f* and the edge of valve-flange *h*, which passage did not exist in the valve B, and fill the chamber above the valve, and thus produce a steam load on the top of the valve of a very uncertain character, whereby the action of the valve became erratic, and the valve chattered and trembled in its closing movement. However, the range of reduction of pressures indicated by the table shows that with the strong spring, to get a reduction of three and a half pounds, the area of the stricture with the valve wide open must be 1.12″; and to get a reduction of six pounds, the area of the stricture must be .8″; while with the weak spring of .4″ compression the area of the stricture must be, respectively, 1.66″ for three pounds reduction and 1.12″ for six pounds reduction. And this shows that with a strong spring the stricture is to be reduced, and with a weak one to be enlarged, just as Richardson says in his patent of 1866.

The means for increasing or diminishing the size of the stricture are in the valve represented in "Exhibit C²;" exactly the means shown in the Richardson patent of 1869, viz, the adjustable screw-ring or sleeve.

I therefore say that the valve shown in "Exhibit Kunkle C²" pre-

sents no substantial differences in construction or mode of operation from the other Kunkle valves formerly considered; that it is substantially like the valves of the Richardson patents of 1866 and 1869 in all material respects; that it works in the same way and accomplishes the same results by the same means; and that prior to the time of the Richardson patent of 1866, no valve had been described which possessed these properties or could produce these results; and that in the Richardson patent of 1866, a valve was described which would produce these results, and the way to produce them was also described; and in the Richardson patent of 1869, an improved means of delicate adjustment was provided to produce these results; and that the description and method of the patent of 1866 has been followed in substance, and very nearly in form; and
177 that the means of the patent of 1869 has been also followed for the same purpose, and with like results.

CHARLES W. FORBES.

UNITED STATES OF AMERICA, *District of Massachusetts:*

BOSTON, *January* —, 1881.

Personally appeared Charles W. Forbes, who, being duly sworn on oath, deposes and says, he has read the foregoing affidavit and subscribed the same, and the same is true, except the matters therein stated on information; and those he believes to be true.

Before me,

[SEAL.] F. F. RAYMOND, 2D,
Notary Public.

(Here follows diagram, marked page 178.)

179, 180, 181 & 182 *Evidence for Complainant.*

Cross-examination of CHARLES W. FORBES, taken in pursuance of stipulation making his affidavit evidence in chief, before John A. Shields, Esq., commissioner United States circuit court, southern district of New York.

UNITED STATES COURT-HOUSE,
New York, October 21, 1881.

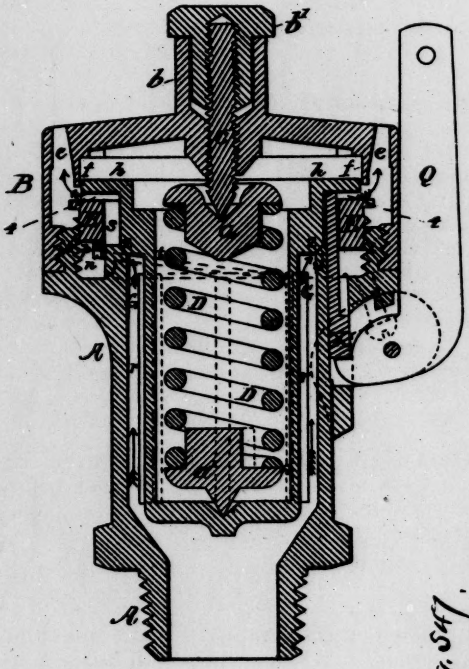
It is hereby stipulated and agreed that the cross-examination of Charles W. Forbes shall take place before John A. Shields, Esq., United States commissioner, southern district of New York.

THOS. WM. CLARKE,
For Complainant.
JAS. H. RAYMOND,
For Defendant.

Present: Mr. Thomas William Clarke, for complainant; Mr. James H. Raymond, for defendant.

Agreed, that the cross-examination may be taken by a stenographer.

Complainants Exhibit Kunkle C.²



No. 547
Consolidated
Safety Valve Co.
v.
Kunkle Page 178.

E. B. Kunkle Pat^ee & Manufr.
Fort Wayne Ind. Pat. May 4 '75. July 21 '7

James E. Munson appointed stenographer to take and extend the minutes of the examination.

(Adjourned till October 22, 1881, at eleven a. m. at Park avenue hotel.)

JOHN A. SHIELDS,
U. S. Commissioner.

NEW YORK, *October* 22, 1881.

Cross-examination by Mr. J. H. RAYMOND, of counsel for defendant:

Cross-int. 1. What is the date of your first acquaintance with the Richardson patent of 1866?

183 Ans. My attention was first called to that patent sometime during the year 1874. I then occupied the position of principal examiner in the Patent Office, in charge of the class of metal working, and was consulted in regard to a reissue application, I think, for the Naylor valve by the examiner in charge of the class of steam engineering.

Cross-int. 2. Did you see the parties, or have any conversation with the parties, who applied for that reissue?

Ans. I think I did.

Cross-int. 3. Who were they?

Ans. Mr. E. H. Ashcroft, who was stopping at the same hotel with me in Washington, asked my opinion as to the form of the claims he had presented in this reissue.

Cross-int. 4. Was Mr. George W. Richardson with him?

Ans. Not to my knowledge.

Cross-int. 5. Was he one of the applicants for that reissue?

Ans. That I don't remember. The first I met Mr. Richardson was in Boston during last year.

Cross-int. 6. Do you know, either of your own knowledge or from information, whether Mr. Richardson was interested in that application for reissue?

Ans. No, I do not.

Cross-int. 7. You first met Mr. Richardson, then, as I understand it, last year, in connection with the case of the Consolidated Safety Valve Company against Crosby?

Ans. Yes, sir; that was my first acquaintance with him.

Cross-int. 8. You are fully familiar, are you, with the state of the art relating to safety-valves prior to the date of the said Richardson patent of 1866?

Ans. I am.

Cross-int. 9. Will you please define a stricture, as the term is used in the Richardson patent of 1866?

Ans. It is the circumferential escape opening between the supplemental chamber and the atmosphere.

Cross-int. 10. What are the mechanical peculiarities of that circumferential escape opening, as shown and described in the

184 Richardson patent of 1866, called by him a stricture; I mean its peculiarities both as to construction and operation?

Ans. It is formed by the outer edge of the extended flange on the valve and the outer edge of the casing of the valve-seat, the stricture being known as the open space between those parts. It forms a contracted passage to the escaping steam from the supplemental chamber outside the ground joint of the valve. Its function is to retard the escaping steam, particularly in the early opening movement of the valve, whereby a pressure of the steam is imparted to the supplemental area.

Cross-int. 11. This stricture, as described in this Richardson patent of 1866, is a necessary part of the invention described and claimed therein, is it not?

Ans. It is.

Cross-int. 12. The stricture is produced mechanically, is it not, by an annular flange or lip, *c c*, projecting beyond the valve seat *e e*, as shown in figure 3 of the patent, and extends slightly below its outer edge, fitting loosely around it, and thus forming the circular or annular chamber *d d*?

Ans. That is a proper reference to the structure shown in figure 3.

Cross-int. 13. In the operation of a valve so constructed, does or does not this stricture remain constant at the initial opening of the valve?

Ans. It does.

Cross-int. 14. Then, after the valve has raised somewhat from its seat, does or does not the stricture commence to widen or open, and allow a more free escape of the steam to the air?

Ans. It is variable, increasing in size at that point of operation.

Cross-int. 15. Then shall we understand in your deposition the term "variable stricture" to mean one which remains constant at the initial operation of the valve, and afterwards opens or widens as the valve is further raised from its seat?

Ans. That is the proper sense in connection with the subject-matter.

Cross-int. 16. Have you examined the opinions delivered by Judge Shepley in the district court of Massachusetts, and by Justice
185 Clifford in the Supreme Court of the United States, in the case of Ashcroft *v.* The Boston & Lowell Railroad Company, the first being found in the fifth volume of the Official Gazette, at page 725, and the second opinion being found in the thirteenth volume of the Official Gazette, at page 865, and do you understand the said opinions?

Ans. I have read the opinions referred to in the question, and believe that I understood them at such time.

Cross-int. 17. Did you examine the arguments of counsel and the record in that case?

Ans. Not fully.

Cross-int. 18. Is it or is it not your opinion that this Richardson patent of 1856 was construed, in those opinions, to be a patent for an open and variable stricture, as you have just defined it?

Ans. Some time has elapsed since reading of those opinions, and I am not now sufficiently familiar with the text to give an answer to that question.

Cross-int. 19. Referring to your *ex parte* affidavit in the injunction papers in this case, which forms by stipulation your direct examination, commencing with the bottom of page 2 and running to the top of page 3, when was the desirability of overcoming the defects of the ordinary safety valve, particularly when held in position by a direct-acting spring, first presented in this art?

Ans. I couldn't say; I have frequently noticed opinions and suggestions upon the defects of the ordinary valve in the literature of steam engineering, and I think the subject has often been discussed in the proceedings of the Institution of Mechanical Engineers, and published in its papers.

Cross-int. 20. The desirability of overcoming these defects was suggested by engineers and others, was it not, long prior to the Richardson patent of 1866?

Ans. Yes; some time prior to that.

Cross-int. 21. Do you find such suggestions in prior patents or prior printed publications; and if so, in what ones?

Ans. I have seen them more particularly stated in the publications of the discussions upon the subject, which can be found,
186 I think, in the "Mechanics Magazine," so far back as 1856 or 1857. I do not now remember, without referring to prior patents, whether these deficiencies in the ordinary valve are referred to in such patents.

Cross-int. 22. Referring to the same affidavit forming a part of the injunction papers in this case, and to the last two paragraphs at page 3, I understand you to say therein that inventors, prior to the Richardson patent of 1866, constructed valves with an annular flange on the periphery of the valve, with such a relation to the valve-seat casing as to form a chamber and have a contracted outlet to the atmosphere which would arrest the current of the escaping steam, and by such arrest causing expansion or recoil action, produce a pressure within said chamber to act upon the additional flange and give greater lift to the valve; am I right? And, if so, state what inventors so prior to Richardson you there refer to.

Ans. The quotation is correct in substance, and examples of such valves are found in the patents of Webster, Green, and Hartley forming a part of the record in this case.

Cross-int. 23. Referring especially to the Green valve which you have just mentioned, do you not find in plate 5 of that patent a supplemental surface beyond the ground joint of the valve in the form of a separate disc or flange connected to the valve, and an intermediate chamber between the flange and the valve with a constricted passage to the atmosphere?

Ans. Yes, sir.

Cross-int. 24. I notice that in your direct examination you consider the Green valve prior to the Webster; is it not true that the Webster patent was one year and ten months earlier than the Green, and should have a prior place in the history of the art to the Green patent, on the face of the papers?

Ans. These patents are referred to chronologically on page 8 of said affidavit; but they are not referred to in that order in following

portions of the affidavit. I can give no reason for this arrangement. I cannot now remember, but do not think I had any particular object in departing from the order of reference recited on page 8.

Cross-int. 25. Referring now to the Webster valve, do you or do you not find therein a supplemental flange which is adjusta-
187 ble, and by means of which the amount of reduction of boiler pressure may be varied within certain limits?

Ans. I do find such a condition of things stated.

Cross-int. 26. Referring to the Webster and the Ritchie patents found in this record, do you find in these two patents suggestions and directions for regulating the reduction of the boiler pressure by means of the supplemental areas, flanges, and strictures of which we have been talking, at least in some degree?

Ans. I do.

Cross-int. 27. You say, on page 4, "Mr. Richardson's invention * * * consists essentially in proportioning said chamber, its horizontal area and its escape opening to each other, and to the degree of tension of the spring." The proportion of said parts to each other then, as I understand you, are the essential features of the invention described and claimed in the Richardson patent of 1866, in your opinion; am I right?

Ans. Yes, sir.

Cross-int. 28. Then your opinion is, that this patent is for a combination of these four parts or elements proportioned to each other, in a certain manner; that is, this chamber in a certain manner proportioned as to its area, to its escape opening, and to the degree of tension of the spring?

Ans. The size of the stricture and the degree of tension of the sgring may be considered the main essential elements for controlling the closing action of this valve. The supplemental chamber may be of greater or less size in relation to the other elements without materially affecting such operation. The valve cannot be controlled by the chamber, but can be regluated in its action either by changing the degree of tension of the spring or the size of the stricture. The only thing to be avoided in connection with the supplemental chamber is that it shall not be so large as to contain too much steam.

Cross-int. 29. I understand you to have just said that the supplemental chamber in this Richardson valve must not be too large. Now, if one should construct a valve in which the supplemental chamber as to its area was smaller than the stricture or escape
188 opening would that valve be in accordance with the Richardson patent of 1866, in your opinion?

Ans. By the term area, as employed in connection with the supplemental chamber, is meant the superficial area of the overhanging flange, which should not be confounded with the cubical capacity of the chamber. The amount of such surface and the pressure beneath it determines the lift of the valve. There might be more or less capacity of chamber beneath it; therefore, what I mean by area in this connection may be smaller than the size of the stricture. The tension of the spring should be weaker in such construction and the

stricture enlarged. I think the condition referred to in the question, as I understand it, would be within the Richardson patent of 1866.

Cross-int. 30. In the quotation which I made from page 4 of your affidavit, you very distinctly say that to come within the Richardson invention of 1866, "it is essential to proportion said chamber, its horizontal area, to the other elements named, namely, the escape opening and the tension of the spring;" do you wish to alter or modify that statement, or are you still of the opinion that said chamber as to its horizontal area should be proportioned to the other two elements, namely, the escape opening and the tension of the spring, in order to comply with the conditions named in the Richardson patent of 1866?

Ans. I think the statement quoted is correct.

Cross-int. 31. What, then, is the proportion called for in the Richardson patent of 1866 as to the horizontal area of the supplemental chamber, with reference to the tension of spring and the size and shape of stricture as shown in said patent?

Ans. In reference to the horizontal area the patentee states, "To the head of the common safety valve, indicated by all that portion of Fig. 2 lying within the second circle from the common centre, I add what is indicated by all that portion lying outside of the said circle, in about the proportion shown in the figure." Not having the patent before me to ascertain what amount of area is contained in the boundary described, I cannot state its extent. Referring to the Crosby record, I find, page 333, dimensions taken from a pho-
189 to-lithographic copy of the drawing from the Patent Office of this Richardson patent of 1866. The area is here stated to be 1.617.

Cross-int. 32. Do you find anything else in the specifications of the Richardson patent, other than the quotation which you have just made, giving this proportion of the horizontal area of this supplemental chamber?

Ans. I do. I find the following paragraph contained therein: "Instead of having the flange or lip *c c* project beyond and extend below and around the outer edge of the valve-seat, as shown in Fig. 3, a similar result may be attained by having the valve-seat itself project beyond the outer edge of the valve-head and terminating it with a circular or annular flange or lip, extending slightly above and fitting loosely around the outer edge of the flange or lip *c c* of the valve-head." Such modification would somewhat increase the area of the valve-head acted on by the escaping steam.

Cross-int. 33. The quotation which you have just made, as I understand it, simply suggests a change in the construction of the flange or lip, the change suggested being that instead of projecting beyond and below the outer edge of the valve-seat, such a flange or lip may be cast upon the outer edge of the valve-head, and extend above and around the outer edge of the flange; and I understand you to say that that construction would slightly increase the horizontal area of the supplemental chamber; am I right?

Ans. That is what I mean. I don't think, however, that the increase would have any perceptible effect.

Cross-int. 34. That is, the proportion of the horizontal area to the tension of the spring and the stricture would be practically the same thing in either construction?

Ans. Yes, sir.

Cross-int. 35. Do you find anything further in the specifications or claim of the Richardson patent suggesting what this proportion shall be?

Ans. There is no more in relation to this feature, except the paragraph following the one first quoted, which refers to Fig. 4. This, however, indicates the same extent of area by different views.

Cross-int. 36. We have then got, in these quotations which
190 you have made from the specifications of this patent, all there is therein indicating what this proportion of the horizontal area of this supplemental chamber should be, have we?

Ans. I think so; I don't see anything else.

Cross-int. 37. Now, the proportion which you have given, namely, 1.617, was taken, as I understand you, from the measurement of a photo-lithographic copy of the drawings of this patent on file in the Patent Office. Am I right?

Ans. Yes, sir.

Cross-int. 38. Then, from the specifications and claim of this patent taken alone and without the drawing, do you find definite data as to what this proportion shall be in measurement?

Ans. No; I do not.

Cross-int. 39. Did you carefully examine the drawings of this patent in the Patent Office?

Ans. I don't know that I ever saw the original patent.

Cross-int. 40. Did you carefully examine and measure the photo-lithographic copies thereof produced in the Crosby case?

Ans. I believe that I did.

Cross-int. 41. Did that copy constitute a working drawing, or a mere illustration or picture?

Ans. A mere illustration. It was obtained at the Patent Office; one of the commercial copies.

Cross-int. 42. It was not, then, in all its parts, a working drawing, was it?

Ans. It was a drawing from which, I should think, a valve might be constructed; but not what we would term a working drawing.

Cross-int. 43. In that drawing what was the overlap of the flange *c c;* that is to say, the distance by which this flange or lip *c c* was separated from the valve-seat? Please state the same in sixty-fourths of an inch.

Ans. It is stated in the Crosby record to be .025 inches, which is a trifle more than one and a half sixty-fourths of an inch.

Cross-int. 44. Please give the decimal?

Ans. It is one and six-tenths sixty-fourths.

Cross-int. 45. Then, you find that the flange in the draw-
191 ings of the Richardson patent is separated from the valve-seat by one and six-tenths sixty-fourths of an inch, do you?

Ans. Yes, sir.

Cross-int. 46. And that for such a stricture the Richardson patent

calls for a horizontal area in a supplemental chamber of 1.617 square inches, do you?

Ans. Yes, sir.

Cross-int. 47. You take these proportions, then, as I understand, from the drawings of this patent, which are not working drawings; am I correct?

Ans. They are taken from the photo-lithographic copy of the patent before referred to.

Cross-int. 48. Do you find, in the specifications or claims of this patent, any such mathematical relations or proportions stated?

Ans. Only in so far as they refer to such parts in the drawing, their extent being indicated between certain lines in the drawing.

Cross-int. 49. Did Mr. Richardson first suggest to you this mathematical proportion between the supplemental chamber, the escape opening, and the tension of the spring?

Ans. No, sir; I never received any information from Mr. Richardson concerning this valve.

Cross-int. 50. Did Col. Clarke, or any other representative or attorney for this patent, first suggest any such mathematical proportion to you?

Ans. Well, I am sure I can't say; I really couldn't remember about how I obtained the information.

Cross-int. 51. Did you find it in Mr. Waters' testimony, or in any prior record or testimony concerning this patent which you examined?

Ans. I can't remember the source of my information.

Cross-int. 52. Is not this theory, as to the proportion between these parts, in fact your own creation?

Ans. They are probably the effects observed by me during my extended experiments with this type of valve, following a careful inspection of the patent.

Cross-int. 53. Did you ever see the theory stated in writing or
192 in print anywhere prior to the time stated by you in your deposition in the Crosby case?

Ans. I think not.

Cross-int. 54. Do you find, in the specifications of this patent, in any one sentence or any one paragraph, a statement which is to the effect that this invention consists in so proportioning these four parts?

Ans. The degree of tension of the spring, the size of the stricture, and the extent of the supplemental surface are referred to in the patent; the capacity of the chamber is not mentioned, for the reason, I believe, that it is not comparatively so material a feature of the construction.

Cross-int. 55. I will modify my inquiry, and ask you to point out the sentence in the specification of this patent which describes a proper proportion between the tension of the spring, the size of the stricture, and the horizontal area of the supplemental chamber, as stated by you on page 4 of your affidavit, to constitute the essential features of the Richardson invention?

Ans. It is not contained in any one sentence.

Cross-int. 56. You then made up this theory, as I understand it, from the quotations you have alaeady given in this examination, from those specifications; am I right?

Ans. Certainly, as to the sum and substance.

Cross-int. 57. Now, do you find anywhere in the specifications of this patent the proportions stated for either the cubic contents of the supplemental chamber, or for its horizontal area for a valve constructed with the spring described in this patent and the stricture one sixty-fourth of an inch wide? If you do find any such proportion mathematically or distinctly stated in the specifications, please state what the proportion is.

Ans. In regard to the chamber, the structure adjacent thereto is referred to, and reference made to a particular figure of the drawing illustrating what is meant thereby. The stricture and spring are alluded to in these words, contained in the same sentence: "This flange or lip *c c*, fitting loosely around the valve-seat *e e*, is separated from it by about one sixty-fourth of an inch for an ordinary
193 spring or balance," which indicates the entire width of the stricture and a degree of tension of the spring which would be readily understood.

Cross-int. 58. Then we do find it mathematically and distinctly stated in the specifications of this patent that the stricture should be about one sixty-fourth of an inch wide: do you find any such mathematical and distinct measurement or proportion stated in these specifications as to any other of the four parts we have been talking about?

Ans. The remaining parts, with the exception of the capacity of the chamber, are referred to in words that state plainly what their size and properties should be, but are not so stated mathematically. For example, the patentee refers to an ordinary spring or balance in connection with the size of stricture mathematically stated, which would be interpreted as meaning a spring that would be compressed one-fourth of an inch when the valve was subjected to 100 pounds of pressure to the square inch.

Cross-int. 59. Then we are not informed, as I understand you, by this patent, what the size, that is, the cubic contents, of the supplemental chamber should be?

Ans. It is only shown in the drawing.

Cross-int. 60. Then, if we have in the specification no information as to the cubic contents of the supplemental chamber, we, of course, have no proportion there given as between its cubic contents and its horizontal area, have we?

Ans. The chamber is not referred to in the specification. The structure is described that includes it in connection with the drawing that shows it. That is all the reference that I observe to this feature.

Cross-int. 61. Please refer to the drawing marked "Complainant's Exhibit Drawing, Kunkle, A," which I now hand you, and say whether it is an exact copy of the said exhibit as contained in your affidavit in the injunction papers in this case.

Ans. I believe it is an exact copy.

Cross-int. 62. Will you please mark the parts in that drawing which correspond to the supplemental chamber, its horizontal
194 area, the escape opening, and the spring, with separate letters, and attach your initials to the drawing, and attach the same to your cross-examination with this date?

Ans. I have done so. *a* small represents the supplemental chamber; *b* small the subplemental surface; *c* small the escape opening or stricture; and *d* small the spring.

Cross-int. 63. Please examine the spring of that exhibit and say whether, in connection with the safety-valve of the size and proportions of said exhibit, said spring is an "ordinary spring," a "strong spring," or a "weak spring."

Ans. I can't judge from the drawing. It has the appearance of an ordinary commercial spring.

Cross-int. 64. In a valve constructed in the proportions and sizes shown in this drawing, would you use a strong spring, a weak spring, or an ordinary spring?

Ans. That would depend upon the application of the valve to a boiler of greater or less size, and the degree of pressure to be sustained.

Cross-int. 65. Suppose you desire to use this valve shown in this drawing with the proportion of parts as shown therein, that is, as to the supplemental chamber and the escape opening, in a boiler with a maximum pressure of 100 pounds to the square inch; would you use in connection therewith a strong sprnig, an ordinary spring, or a weak spring?

Ans. If I desired an extended lift to the valve, and was not very particular about the amount of reduction in the pressure, I should employ a weaker spring.

Cross-int. 66. Suppose you desired to use a valve of the size and proportion shown in this drawing on a boiler with a maximum pressure of 100 pounds to the square inch, and desired the pressure to be reduced in the boiler not to exceed five pounds when the valve was operated; would you put into the valve of the construction so shown an ordinary spring, a strong spring, or a weak spring?

Ans. I can't tell. I don't remember the size of the stricture which would control the valve within the amount of reduciion stated with either an ordinary, strong, or weak spring.

195 Cross-int. 67. Give the size and proportion of the supplemental chamber and escape opening to the atmosphere shown in this drawing, do you find in the Richardson patent any rule which would instruct you as to whether to put into such a valve so constructed an ordinary, a strong, or a weak spring, to accomplish the purposes stated?

Ans. The size of the stricture would be all the data necessary to select a proper spring to be applied.

Cross-int. 68. Then I understand you to say that the rule of proportions as laid down in Richardson's patent, as the same is construed by you so far as the spring is concerned, to relate to the size of the stricture; that is to say, that this matter of proportion, so far as the spring is concerned, relates to the stricture only, and that

there need not necessarily be any proportion between the strength of the spring and the supplemental chamber in order to comply with the Richardson rule as developed by you?

Ans. I don't mean to be understood as saying that the spring and stricture are the only essential elements to be considered. A sufficient amount of supplemental area is of course necessary to give a proper lift to the valve.

Cross-int. 69. Now, Mr. Forbes, we will go back to our text. On page 4 of your affidavit so often referred to, you state that the essence of the Richardson invention is the proper proportioning, each to the other, of the following four parts; namely, the supplemental chamber, the horizontal area, the escape opening, and the tension of the spring; and I will ask you again whether you desire to alter or modify that statement?

Ans. The features enumerated on page 4 and referred to in the question are all essential in the structure of this valve, and should be properly proportioned. The spring and stricture require a more careful adjustment with each other than the chamber or supplemental surface with either the stricture or spring. In other words, more latitude may be given to the size of the chamber or extent of supplemental area than with either of the other features.

Cross-int. 70. With this explanation then you adhere still,
196 do you, to the statement contained on page 4, which was quoted in the last question?

Ans. It appears to be correct; I don't see any reason to change it.

Cross-int. 71. Then please take the drawing, "Complainant's Drawing, Kunkle, A," which you have just marked, and state whether, for a valve with the supplemental chamber and its horizontal area and the escape opening there shown, you should use a strong spring, a weak spring, or an ordinary spring to fill out or complete the proper proportions for a safety valve as laid down in the Richardson patent.

Ans. In judging merely from the appearance of the drawing, and after considering the service that I wish the valve to perform, I might be able to state whether the spring therein shown was a weak, a strong, or an ordinary spring; but as the matter is presented in the question, I can't state which I should use, the conditions being too indefinite, as well as my knowledge, of the size of the parts referred to in the valve shown.

Cross-int. 72. Are you not able with all your experience with safety valves, and after your study of this Richardson patent of 1866, and after an examination of the parts named as shown in this drawing, to determine whether a strong spring, a weak spring, or an ordinary spring should be used to make the valve shown in this drawing equivalent to the Richardson patent of 1866, so far as the results to be produced are concerned?

Ans. I am not able to select a spring to suit a given reduction of pressure; either a weak, ordinary, or strong spring would cause the valve to operate similar to a Richardson valve; but in regard to obtaining a definite result in the amount of reduction of pressure, I could not select the spring that would produce such a result.

Cross-int. 73. Given a supplemental chamber with a horizontal area and escape opening of the size, shape, and proportions shown in this drawing, and it being desired to complete the valve by the addition of a spring, so that the valve in operation will close with a reduction of five pounds or less of pressure, does the specification
197 of the Richardson patent of 1866 instruct you whether to adopt a strong, a weak, or ordinary spring?

Ans. It does not in so many words.

(Adjourned.)

NEW YORK, *October* 24, 1881.

Cross-int. 74. Referring again to "Complainant's Exhibit, Kunkle, A," given a supplemental chamber of the size and proportions shown in that drawing, and supposing the spring to be an ordinary spring, as you have defined it, what should be the width of the escape opening to produce a stricture identical with that of the Richardson patent of 1866 (hands witness paper), so to complete the valve as to make it in operation equivalent to the Richardson patent of 1866?

Ans. The comparative result cannot be determined by the width of the stricture. The size of the stricture would be a factor in determining this question, and without knowing the diameter or circumference of the stricture shown, I cannot give an answer.

Cross-int. 75. We will suppose that the spring shown in that drawing is an ordinary spring which, with a hundred pounds' pressure in the boiler to the square inch, would be compressed one quarter of an inch. Now, given a supplemental chamber with its horizontal area of the size and proportions shown in that drawing, does the Richardson patent of 1866 instruct you as to what size or proportion of an escape opening to add to complete a valve which shall be identical with the Richardson valve in operation?

Ans. Yes, sir; it does.

Cross-int. 76. What size and proportion of an escape opening would you add to such a valve to so complete it?

Ans. That would depend upon the degree of reduction of pressure desired.

Cross-int. 77. I understand you to have frequently testified, both in this and in the Crosby case, that the object of the Richardson invention was to construct a valve so that, in operation with a hundred pounds' pressure to the square inch, it would close with a reduction of five pounds, or less, in boiler pressure, and that the
198 essence of Richardson's invention of 1866 was in so proportioning four parts to each other as that they would accomplish this result. And you have just stated that the three parts named, to wit, first, an ordinary spring of a quarter of an inch in compression under one hundred pounds of steam pressure; second, a supplemental chamber of the capacity shown in this drawing, and, third, its horizontal area in the proportion shown in this drawing, being given, the Richardson patent instructs you as to what size and proportion of escape opening to add to complete a valve, so as to attain the object of the Richardson invention. Now I want to know, for such a valve as shown in this drawing, as to these three parts,

what the size and proportion of the fourth part should be; or, in other words, what the Richardson patent instructs you to add for the escape opening to complete a valve which would so operate.

Ans. The Richardson patent does not contain data from which a definite degree of the reduction in the boiler pressure is obtained. Sufficient data is given to construct a valve that will operate as desired, and directions are also contained in the patent as to what should be done to regulate the degree of reduction of pressure in connection with springs of different tension. The patentee has stated very clearly what he considers to be the essential width of the stricture or escape opening in connection with an ordinary spring to cause the valve to operate as desired, and then states that it is essential to diminish the size of the stricture when a stronger spring is used, or to increase its size when a weaker spring is employed.

(Objected to, as not responsive.)

Cross-int. 78. Would a mechanic, skilled in the art, and having a valve constructed, as to the three parts named in the last question, as stated in the last question, be informed and instructed, from reading the Richardson patent of 1866, definitely, as to what size and proportion of an escape opening to add in order to so complete the valve as that it would answer the purposes named?

Ans. Without doubt.

Cross-int. 79. For the valve shown in this drawing, and supposing the spring to be an ordinary spring, as stated in the Rich-
199 ardson patent and defined by you, would the mechanic, skilled in the art, and following the instructions of this patent, add an escape opening thereto, for the purposes named, one sixty-fourth of an inch wide?

Ans. He could do so and produce an operative device.

Cross-int. 80. Do I understand you then, that the instructions and information contained in the Richardson patent of 1866, to the manufacturer, are, that for a valve having an ordinary spring, and the other two parts named, of the size and proportions as shown in this drawing, that he should add an escape opening one-sixty-fourth of an inch wide; is that the direction contained in the specifications of this patent?

Ans. (Referring to book.) No, sir; there is nothing of that kind here.

Cross-int. 81. What instructions does this patent give to the manufacturer as to the size of the escape opening to be added in a valve of the size, proportion, and shape shown in this drawing, if any?

Ans. There is no allusion to any particular-sized valve in the patent, that I observe, except the size indicated by the illustration.

Cross-int. 82. Mr. reporter, will you please repeat to the witness cross-question No. 77; and Mr. Forbes, will you please give me a definite answer thereto?

(Cross-question 77 repeated to witness.)

Ans. I do not wish to be understood as stating that the Richardson patent of 1866 lays down definite data from which any given-sized valve may be constructed to operate with a definite degree of

reduction of pressure. Such a result cannot be determined from the Richardson patent.

Cross-int. 83. Then I understand you that the Richardson patent does not sufficiently instruct the manufacturer in advance as to the exact proportion or size of the escape opening, to add to the other three parts of this drawing, in order to construct a valve which, when completed, will operate with a reduction of boiler pressure which he may desire?

Ans. No, sir.

Cross-int. 84. In the experiments which you made with the
200 Kunkel valve ("Exhibit B"), what was the compression of the spring per hundred pounds, in inches, which you used?

Ans. Five thirty-seconds of an inch.

Cross-int. 85. Where did you get that spring?

Ans. If I remember, this spring was obtained at the works of the Ashcroft Manufacturing Company, in Boston.

Cross-int. 86. Are you or are you not aware of the fact that the spring which came with this valve ("Exhibit B") from Mr. Kunkel's shop would be compressed five-eighths of an inch by a hundred pounds' pressure?

Ans. The spring connected with the valve that was represented to me as coming from Mr. Kunkel's shop sustained a compression of four-tenths of an inch, under the condition stated, according to my measurements.

Cross-int. 87. Referring to this drowing, to the part which you have marked A, which I will call "step A," thereby forming a serpentine port, do you find any such step in any of the patents prior to Kunkle's, which you have examined?

Ans. I do not remember having noticed such construction.

Cross-int. 88. In "Kunkle Exhibit Drawing A," does the pendent flange or lip project downwards below the top of the valve casing which surrounds the valve seat?

Ans. It does not; it is drawn directly on the horizontal line.

(It is agreed between counsel that the witness Forbes shall examine "Complainant's Exhibit Webster No. 1 and No. 2," to see that no alterations had been made in them since the experiments with them conducted by the witness, and that he shall send the same by express to Mr. J. C. Hoadley, engineer, &c., Boston, in the same condition in which said exhibits were when witness made his experiments with them, for the purposes of examination and experiment by said Hoadley, and that witness shall take such measurements of said exhibits as will enable him to determine, after such examination and experiments by Mr. Hoadley, whether the same were altered in any respect; and the witness consents so to do.)

Cross-int. 89. Is it not the necesssry practice in the manufacture of safety valves, under any and all of the patents which
201 you are acquainted with, that the same, after being made, should be tested and experimented with, and be adjusted in their several parts, before they are sent out?

Ans. That is the usual practice.

Cross-int. 90. Is it not true as to every experiment which has so far been reported in the record in this case, that the first part of the experiments has been devoted to adjusting the valve and springs?

Ans. It has been my practice to make a preliminary test in order to ascertain the normal condition of the operation of the valve.

Cross-int. 91. I quote from the specifications of the Richardson patent of 1866, as follows:

"To the head of the common safety valve, indicated by all that portion of figure 2 lying within the second circle from the common centre, I add what is indicated by all that portion lying outside of the said circle in about the proportions shown in the figure."

Does not that language, Mr. Forbes, imply adjustment and experiment?

Ans. It undoubtedly implies that the figure embraces the preferred proportions of such parts.

Cross-int. 92. Did you ever make or see a safety valve having the exact proportions, as to the valve-head and extended area, shown in figure 2 of this patent?

Ans. I do not remember whether the Richardson valve that I have experimented with was constructed in strict accordance with the parts referred to as shown in the patent.

Cross-int. 93. Is the best of your recollection, that you have or that you have not seen a valve made in strict accordance with the proportions of figure 2 of said patent, as to the parts referred to?

Ans. If I remember correctly, the Richardson valves with which I experimented were constructed substantially within the proportions stated in the patent.

Cross-int. 94. Were they exactly in the proportions not stated in the patent, but shown in figure 2, as to these two parts?

Ans. I cannot say.

Cross-int. 95. What is the best of your recollection?

Ans. My recollection is that they were intended to be the same.

Cross-int. 96. The same as what?

202 Ans. The same as those illustrated in the patent, except they were of larger size, but proportionately the same in their parts.

Cross-int. 97. You pretend to say that in Richardson's valves, with which you experimented, you followed exactly the proportions between the valve-head and the extented area shown in figure 2 of the drawings of this patent?

Ans. The Richardson valves that I experimented with were taken from the shop in their regular course of manufacture for the trade, and my recollection is that this relative proportion of parts was found to exist in these valves. I have never seen a valve made strictly in accordance with the size of parts indicated in the patent drawing, in fact, have never seen the patent drawing itself.

Cross-int. 98. Is not the proportion referred to in the specifications of the patent merely an approximate proportion, the drawings not being working drawings, and does not the language, "in about the proportion shown," imply experiment and adjustment?

Ans. That, I think, is the proper interpretation of the language.

Cross-int. 99. Will you please state, in the language of the specifications of the patent, as contained in the second paragraph, after the statement of invention therein, the purpose of diminishing the escape opening for a strong spring, and increasing it for a weak spring?

Ans. (Reading.) "To regulate the escape of the steam as required."

Cross-int. 100. Mr. Forbes, I quote the following from the specifications of the Richardson patent of 1866, which constitutes his statement of invention: "The nature of my invention consists in increasing the area of the head of the common safety valve outside of its ground-joint, and terminating it in such a way as to form an increased resisting surface against which the steam escaping from the generator shall act with additional force after it has lifted the valve from its seat at the ground-joint, and so, by overcoming the rapidly increasing resistance of the spring or scales, insure the lifting of the valve still higher, thus affording so certain and free a passage for the steam to escape as effectually to prevent the bursting of the boiler or generator, even when the steam is shut off and the
203 damper left open." The last sentence of the next paragraph, the first part thereof being devoted to describing details of construction, is as follows: "This increased area may be made by adding to a safety valve already in use, or by casting the whole entire." The next paragraph contains the quotation which you made in answer to my last question. The next paragraph states: "With my improved safety valve, constructed as now described, * * * the steam * * * acts against the increased surface of the valve-head, and by this means, together with its reaction, * * * it overcomes the rapidly increasing resistance of the spring or balance, lifts the valve still higher, and escapes freely into the open air, until the pressure in the generator is reduced to the degree desired, when the valve will be immediately closed by the tension of the spring or balance;" the closing sentence of this paragraph and as well of the specifications being as follows: "The escape of the steam by means of this safety valve is so certain and free that the pressure of the steam in the generator or boiler will not increase beyond the point or degree at which the valve is set to blow off." Now, have I stated fully and fairly all the language of this patent which tends to enlighten us as to the nature and purpose of the invention claimed therein?

Ans. I think so.

Cross-int. 101. Referring now to the language of the last paragraph of these specifications as just quoted, are you not of the opinion that the language, "The pressure * * * is reduced to the degree desired," as used by Mr. Richardson, referred not to the degree of working pressure of steam in the boiler desired to remain after the operation of the valve, but to the degree of steam thus allowed to escape for the purposes of safety; are you not of the opinion that that purpose was in the mind of Mr. Richardson when this language was used in this specification? I am not now referring to your use in your opinions, or affidavits of testimony heretofore

given, of this language, but to the plain interpretation of the meaning of Mr. Richardson, or his solicitor, evidenced by this language in the specifications.

Ans. The language referred to appears in the clause of the specification defining the action of the steam and the operation of
204 the valve, and refers particularly to the pressure in the generator at the closing point of the valve. It is well known, and was generally understood at the time this patent was granted, that a safety valve would close only at a point below the pressure in the generator at which it was adjusted to open. Therefore the words evidently refer to the amount of reduction of pressure in the generator that permitted the valve to seat itself in its closing operation.

Cross-int. 102. (Question repeated, with special reference to that portion of it referring to the working pressure remaining in the generator after the valve had closed.)

Ans. In considering the description and directions given in the preceding paragraph of the specifications my opinion is that Mr. Richardson's aim was to prevent a loss of the working pressure in the closing movement of his valve, for the reason that he gave directions as to the contraction or enlargement of the stricture, in order to regulate the escape of steam, which would directly affect the amount of reduction of pressure. I do not see any reason for permitting a greater reduction of pressure than could be practically avoided, as the question of safety does not lie in this direction, but rather the object to preserve all the steam possible after the pressure in the generator had receded to its working point.

Cross-int 103. I am not asking you, Mr. Forbes, as to your theories of the construction or operation of the best safety valve now known in this year of grace, 1881, but as to the plain, fair interpretation of the language of the specifications of the patent which I have quoted, and as to the meaning and purposes of Mr. Richardson in employing that language you have stated in the commencement of your last answer, that, considering the language of the preceding paragraph of the specifications, you are of opinion so and so. Now, have you any other reasons drawn from the language of the specification for that opinion? If so, please state them.

Ans. I believe I have stated my reasons fully, and in view of them, as already given, think that Mr. Richardson's object was to maintain the working pressure in the boiler at a practical uniform range.

Cross-int. 104. Will you please state in the language of Mr.
205 Richardson, as employed in his patent No. 85963, granted in 1869, in the third paragraph thereof, the nature and object of his patent of the 25th of September, 1866?

Ans. He states that "said patented invention relates to a means for providing a more free escape for the steam than could be obtained by safety valves as constructed prior thereto, and to insure the keeping of the valve open until the pressure of the steam in the boiler or generator falls below the pressure which was required to open it."

Cross-int. 105. Will you please now quote from the Richardson patent of 1866 any and all the language contained in the specifications thereof, suggesting or directing, in terms, the purpose of preventing a reduction of the steam pressure in the boiler below what is necessary or desirable for working purposes, by the operation of his valve?

Ans. The patentee does not state, in terms, that an object of his invention was to cause his valve to close as near the point at which it was adjusted to open as would be practicable. Therefore the inference must be drawn from the suggestions contained in his description of its construction, and in considering that no reason can be given for permitting the valve to discharge a greater quantity of steam than is necessary to maintain the pressure in the boiler at the point of comparative safety, which is usually the point at which the valve is adjusted to open. I have no doubt but that the construction shown and described will cause the valve to close as near the point at which it was set to open as possible. I consider the result secured an inevitable function of the construction shown, to say the least

Adjourned.

NEW YORK, *October* 25, 1881.

Cross-int. 106. Referring to your affidavit, which constitutes your direct examination in this case, your description and statement therein of the variable stricture and of the opening action of the Richardson valve is, I think, correct, and in accordance with the decision of the Supreme Court in the case of Ashcroft against the Boston and Lowell Railroad Company. But as to the closing
206 action of the valve as described by you in that affidavit, was not the ingenious theory and statement therein contained original with you?

Ans. It was.

Cross-int. 107. Do you find any such statement or definition of the closing action of this valve in the Richardson patent of 1866, or in Mr. Waters' testimony, or in any of the testimony or briefs in these cases prior to the date of your said affidavit?

Ans. The theory advanced by me as to the closing action of the Richardson valve had never before been explained, to my knowledge, by any person, or in any written or printed publication.

Direct examination resumed:

Int. 108. Notwithstanding you do not find specifically stated in the Richardson patent that the area of the extended surface, the capacity of the supplemental chamber, the tension of the spring, and the area of the stricture ought to bear certain proportional relations to each other, have your observations upon the working of safety valves containing these elements of construction satisfied you that the proportional relations between these things have a governing action upon the operation of such safety valves?

Ans. My observations convinced me that the action of these valves is governed by such conditions. In the case of the Consolidated

Safety Valve Company *v.* The Crosby Steam Gage and Valve Company, I made trials of two valves of the same size, with springs of an equal degree of tension, at the same time, at the same place, and under precisely the same circumstances. These valves were respectively a Richardson valve and a Crosby valve, which are somewhat different in construction and relative arrangement of parts, but contain in common the main essential elements necessary to their operation. I found, during the tests and experiments, that such valves in their operation, both in the opening and closing movement, were identical in action and susceptible to the same changes in their action by precisely the same method of adjustment. It occurred to me that two such valves applied to the same boiler operated under the same pressure, held to their respective seats by the same kind and quality of spring, and producing identical results, that
207 there must exist intermediate conditions and effects within the structure to have produced these identical effects; and I actually found, by comparative measurements of the supplemental surface that was affected by the recoil action of the steam, the size of the stricture, the pressure within the supplemental chamber, bore certain proportions to each other in the respective valves, and that such proportions were relatively and substantially the same. This law or rule was assailed by the counsel for the defence in a case cited, under a misconception of the facts. For example, I assumed in that case that the supplemental area acted upon by the escaping steam, controlled by the constricted passage, was upon the bottom surface of the depending plug in the cell of the Crosby valve, it being evident that the recoil action of the steam, produced by partially closing the escape passages to the atmosphere, could only be felt upon this part of the supplemental surface, the pressure in the cell being eighty-five pounds per square inch directly adjacent to this surface, while the remaining portion of the supplemental surface is located directly adjacent to the ground-joint of the valve, and only susceptible to the boiler pressure of one hundred pounds per square inch. I was convinced that the effects of the recoil action of the steam in the Crosby valve could not be felt beyond the point within the cell, wherein the pressure in the bottom of the cell of eighty-five pounds per square inch was met and repelled by the greater pressure of one hundred pounds per square inch from the boiler. The reference in that case to a particuler trial, upon which my rule of three, so called, was based, omitted the variation recorded in the amount of the reduction of pressure as compared to the corresponding trial with the Richardson valve. The same reasons have been set forth in this controversy relating to the comparative causes, and which I believe to be a true solution of the matter.

(Defendant's counsel objects to all of said answer, except the first sentence thereof, as not responsive, and as immaterial and irrelevant in this controversy, and moves to strike out the same.)

Int. 109. In making springs of the character used in these valves is it or is it not easy to obtain a spring of exactly a definite compression or tension for a given pressure per square inch of a

208 valve; or, in other words, is it or is [it] not difficult to get two such springs as are used in these valves exactly alike?

Ans. It is difficult to do so.

Int. 110. Looking at the drawing of the Richardson patent of 1866, to which your attention has been called, do you not find that the ratio between the diameter of the steam-way in that drawing and the diameter of the additional area within the lip of the stricture is substantially like the diameters of similar portions adopted in the Richardson valve in practice, while the extent of the valve-seat shown in the drawing is larger than the extent of the valve-seat usually adopted in practice?

Ans. I do find such to be the case.

Int. 111. Now, taking a valve with a given strength of spring and a given size of stricture, and trying it upon a boiler, if you should find that the valve lifted too high and discharged too much steam in the operation, or did not lift high enough and did not show promptness in opening and closing, do you think a person skilled in the art of making safety valves could correct such working of the valve without changing the spring, by regulating the size of the stricture, from any instructions contained in the Richardson patent, or by changing the strength of spring and size of stricture both?

Ans. I have no doubt but that the patent contains sufficient and definite instructions as to what should be done to make the desired corrections mentioned in its operation.

Cross-examination resumed:

Cross-int. 112. Referring to your answer to question numbered 109, do I understand that the valves with which you have experimented in this case, compared to each other, are not so identically in the proportion of their parts and the tension of the springs as the valves with which you experimented, and to which you refer in said answer?

Ans. In relation to the tension of the spring, there is a slight variance; the remaining elements, I believe, are substantially the same.

(Cross-int. 112 repeated.)

209 Ans. I do not find any substantial difference, except in the tension of the springs in the valves in this case.

Cross-Int. 113. But in their relative proportions as to the parts named in your answer referred to, that is, the ratio of areas, &c., and tension of springs, did you not find the Crosby valves more similar to the Richardson valve than the valves compared in this case?

Ans. No, sir; the rule applies in both cases.

CHARLES W. FORBES.

Sworn to before me.

JOHN A. SHIELDS,
U. S. Commissioner and Examiner for the Southern District of New York.

(It is agreed between the counsel for the parties to this cause that the stenographer shall sign the engrossment of this deposition for the witness, the same having been fully read over to him; and also that the same may be retained by counsel for the complainant until the final hearing in this case.)

Opinion of the Court. April 30, 1881.

LOWELL, *J.*

The complainant charges against the defendant an infringement of two patents granted to George W. Richardson for improvements in safety valves for steam boilers; one dated September 25, 1866, No. 58294, and the other dated January 19, 1869, No 85963. The former patent is the important one. The other is for a device to assist in adjusting certain parts of the patented valve.

Richardson's valve went into general use upon the locomotives of this country and of Europe immediately upon its intaoduction to the market, and is still made and sold very extensively.

The defendant holds two patents granted to George H.
210 Crosby, one dated January 26, 1875, No. 159,157, and the other dated February 23, 1875, No. 160,167.

The questions argued in these cases are, whether Richardson's patents are valid, and if they are, whether Crosby's patents represent subordinate or independent inventions.

The plaintiff's invention has been twice before this court. In Ashcroft *v.* Boston & Lowell R. R. Co., 1 Holmes, 366, the owner of the safety valve patented by Naylor in 1863 sued to enjoin the use of the Richardson valve; but the court held that the two were distinct inventions. This decision was affirmed in the Supreme Court. Ashcroft *v.* Railroad Co., 97 U. S., 189. Another suit, in which Richardson was plaintiff and Ashcroft defendant, was pending at the same time, upon the same evidence, and was decided, in January, 1875, in favor of the plaintiff. Judge Shepley's opinion was orally given, and no minutes of it are preserved. From the reports of the former case. and the additional testimony in this record, the state of the art is pretty fully exhibited.

The ordinary safety valve, still used upon certain kinds of boilers, and which consists of a valve kept down by a lever and weight, or by a spring balance, was not wholly satisfactory, nor always even safe when used with a helical spring, which is much the most convenient load for the valve of a locomotive. When steam is made very rapidly, this valve will not open fast enough to reduce the pressure of the boiler, because the pressure of the spring is constantly increasing by its compression.

To meet this difficulty several inventors, before 1866, constructed and patented valves which had an additional surface, outside of the valve proper, to be acted on by the steam as soon as it had raised the valve, and thus to increase the lift as the force of the spring increased. Naylor's specification, as cited by Judge Shepley, 1 Holmes, 368, described a valve which was made to project over the edges of the exit passage for the steam; and the projecting edges of the valve were made to curve slightly downward, so that the steam, on issuing

between the valve and its seat, would impinge against the curve projecting portion of the valve, and would be deflected into an
211 annular chamber which surrounded the central passage for the steam. He said that he thus made use of the recoil action of the steam against the valve; but he gave notice that he did not claim broadly this use of the recoil action and of the extension of the valve laterally beyond its seat. In fact, these two features were found in Beyer's patent, which was issued a few months earlier than Naylor's. Ashcroft, the assignee of Naylor, was less modest. When he reissued the patent, he claimed the valve with its downward curved lip and the annular recess, adding, by way of caution, "substantially as described." The courts held that, in view of what Beyer had described and patented, Naylor could not sustain a broad claim to a curved lip or an annular recess generally, but must be limited to his own peculiar form of construction.

Richardson's patent of 1866 embodied the same general mode of construction and operation as was shown in Beyer and Naylor, and in other patents now produced in evidence. Judge Shepley thus describes it:

"In the Richardson valve, when the valve opens, the steam expands and flows into the annular space around the ground-joint. Its free escape is prevented by a stricture, or narrow space formed by the edge of the lip and the valve-seat. Thus the steam escaping from the valve is made to act by its expansive force upon an additional area outside the valve proper, to assist in raising the valve; this stricture being enlarged as the valve is considerably lifted from its seat, and varying in size as the quantity varies of the issuing steam." (1 Holmes, 569.)

The difficulty to be overcome in all these valves which use an additional lifting area after the valve is open, is to limit the lift so that too much steam shall not escape. It seems that Richardson's valve accomplished this by a careful adaptation of the width of his opening or stricture to the size of his chamber and the strength of his spring. In the reported case Judge Shepley said, and Mr. Justice Clifford in the Supreme Court agreed with him, that Richardson had succeeded in making a working valve of this kind which would lose but two and a half pounds when blowing off at a pressure of one hundred pounds. The validity of Richardson's patent
212 was not in issue in that case, but only a comparison of his valve with that of Naylor, owned by Ashcroft. In Richardson *v.* Ashcroft, which is not reported, and which was not taken to the Supreme Court, Judge Shepley sustained the patent. He must, therefore, have found that the specification of Richardson was sufficient, and that he was the first to invent whatever the court considered to be claimed by him; but exactly what that was I am not informed.

In this record the defendant introduces two English patents not brought out in Richardson *v.* Aschcroft, and have examined two accomplished experts in relation to them. They also produce the American reissued patent of Waterman, which I suppose to have been before Judge Shepley in connection with the state of the art, but which, if we may judge from the pleadings, was not relied on to

defeat the novelty of the Richardson patent. The original patent of Waterman, which was considerably older than Richardson's, while claiming an improvement to a different part of the valve, showed a structure so much like Richardson's that Richardson sought out the inventor and they made a joint stock of their two patents, and procured a reissue of that of Waterman, in which he specifies a mode of construction by which, when the valve is raised from its seat, the escaping steam is so directed as to enter an overhanging or projecting annular chamber on the top or upper part of the valve, and outside of and beyond the ground-joint. He describes how this force may be modified by a modification of the overhanging or projecting annular surface. He goes into all the details of the necessary and proper construction, and, in short, as I understand it, describes the Richardson valve, with a stricture and all, excepting that his additional lift was due wholly to the expansive power of the steam admitted to the annular chamber, while Richardson used both the impact of the issuing steam and its subsequent expansive power. Naylor had used the impact only.

The two patents newly found in this case are those of Ritchie and of Webster. Both describe and show by drawing valves intended to operate in the same general way with those of Beyer, Naylor, Waterman, and Richardson. The experts have produced many valves said to have been made from those descriptions and drawings, with more or less change. Mr. Hoadley, called by the
213 defendant, considers the description and drawings in Webster to be as explicit and easy to be followed as those of Richardson. Either description, he thinks, would require to be supplemented by experiment before a working valve could be made. Richardson's patent, however, has been sustained by the court, and Webster's has not been.

My opinion upon the issue of infringement makes it necessary for me to explain at large the conclusions concerning the state of the art—at which I have arrived after a patient study of the record—excepting to this extent: I consider it to be fully proved that some valves had been made before 1866, which operated on the same general principle with that of Richardson, and were of some value. Especially is this true of the Naylor and Waterman contrivances, and probably of Beyer's. Waterman, I may say, is examined as a witness for the complainant, and says, in direct examination, that his valve was not good for much until he changed it with Richardson's patent in his hand. On cross-examination he says that the chief difference betwen his valve and Richardson's was, that he had a weight and not a spring; and he testifies that the arrangement for joint ownership was made with Richardson upon his threat to reissue his patent and claim the use of the spring. He means to say, I suppose, that the spring was a well-known equivalent for a weight, as it undoubtedly was. Richardson was twice examined, but says nothing on this subject. If Waterman wishes us to understand that his original invention was useless, he is contradicted by his oath to the reissue. I find that Waterman had a valve of some value, operating through the expansive power of steam exerted upon an ad-

ditional chamber outside the ground-joint. Richardson assisted in procuring a reissue of this patent; and he set up the Beyer patent in answer to Ashcroft; by which we may infer that he considered both these inventions to be of some value.

In this state of the art, Richardson describes an annular chamber outside the ground-joint of a valve, and so regulated by the crack, or opening, between its lip and the main body of the valve, that it will confine or "huddle," as the experts say, the steam, when it begins to escape from the chamber, and will presently afterwards open more widely and let the steam escape, and not interfere
214 with the rapid fall of the valve before it has lost too much steam. It holds up just long enough. His single claim is "a safety valve with the circular or annular flange or lip *c c*, constructed in the manner, or substantially in the manner shown, so as to operaet as and for the purpose herein described."

The Crosby patents, owned and used by the defendant, describe two forms of valve operating substantially alike, and which I can describe sufficiently without nicely discriminating between them. The valve is so made that when it rises, an additional part of its under surface is exposed to the action of the steam in the chamber. This additional part is either masked or neutralized until the valve begins to rise. This furnishes an additional lift, proportioned to the additional area now exposed. The pressure of the steam in the chamber is further regulated and adjusted, thus: When the valve rises, it opens a way for the steam into a smaller chamber inside the principal one. This lesser chamber has several outlets to the air below, the sum of whose area is about equal to that of the lesser chamber itself. If these holes are all open, there is simply a free escape of steam below as well as above, though not of the same size; and the operation is like that of an ordinary old fashioned valve, except that it has a vent below as well as above. But in practice the holes are rarely left wide open; and the most approved means of closing them to the desired extent are found in a brass ring or sleeve, fitted by a screw thread to a thread on the outside of the casing. In the second patent, this sleeve is described instead of the stop-cocks and bushings mentioned in the first patent. "This sleeve is of cup shape, or has an upturned annular flange, which directs upward the escaping steam." When these holes are thus diminished, there is a "huddling" of steam, as the plaintiff calls it, or a differential pressure, as the specifications describe it. That is, the amount of pressure which will be exerted on the valve is adjusted, in part, by the size of the openings below.

Now it is plain that this contrivance does not come strictly within the language of the plaintiff's claim of a safety valve, with the circular or annular lip, &c. The curved lip or flange in the defendant's valve, when he uses it, has nothing to do with the pressure of
215 the steam. It merely prevents it from scalding the engineer. There is a lip or flange in the plaintiff's valve, as actually constructed, which serves this purpose, but which is not the flange mentioned in the claim. The plaintiff's *claimed* flange co-operates in the making of his stricture; the defendant's flange is merely attached to the

sleeve which aids in making his stricture. But the important comparison is between the two things. If the defendant has taken the plaintiff's invention, I should try to construe the claim to conform to the fact, rather than to leave the parties to the dubious expedient of a reissue.

I understand the resemblances and differences to be these: The defendant, like the plaintiff, employs an additional surface to lift the valve as soon as it begins to blow; and the pressure is regulated, in part, by a stricture. The defendant's valve is unlike the plaintiff's in the following particulars: The additional area is not outside the ground-joint, but inside; it is not acted on independently of the valve itself, but is a part of it; the escaping steam does not act at all by impact, but wholly by expansion; the stricture is not variable, opening wider as the power increases, but is adjusted once for all by the operator.

Considering the state of the art, as I have found it to be, that Richardson was not the first to invent and apply, more or less well, the principle of the additional area, nor that of the stricture, he could not, whatever the words of his claim, successfully enjoin the use of a valve resembling his own only in its adoption of these general ideas.

I am of opinion, then, that Richardson neither claims, nor could properly claim, a valve having such a mode of operation as I find in this valve of defendant.

Case No. 1199 depends upon the decision of No. 1184, because the improvement which forms the subject-matter of that suit is merely a mode of adjusting the pressure in the valve which is the subject-matter of the patent sued on in No. 1184.

Bills dismissed with costs.

A true copy.

[SEAL.] Attest: JOHN G. STETSON, *Clerk.*

216 UNITED STATES OF AMERICA, *Southern District of New York,* } ss:

I, John A. Shields, United States commissioner and examiner, duly appointed by the circuit court of the United States for the southern district of New York, do hereby certify that the foregoing are the proofs for final hearing, taken before me in the above-entitled cause on the part of the complainant, under and pursuant to the sixty-seventh rule of the Supreme Court of the United States as amended.

I do further certify that I am not of counsel nor attorney for either of the parties, nor in anywise interested in the event of said cause.

I further certify that Mr. Thos. Wm. Clarke appeared on the part of complainant, and Mr. J. H. Raymond appeared on the part of defendant, in the taking of said proofs.

JOHN A. SHIELDS,
United States Commissioner and Examiner.

217 *Stipulation*

United States Circuit Court, Northern District of Illinois. In Chancery.

THE CONSOLIDATED SAFETY VALVE CO. *v.* ERASTUS B. KUNKLE.

It is hereby stipulated and agreed that the deposition of Mr. John C. Hoadley, an expert on behalf of the defendant herein, may be taken before F. F. Raymond, 2d, a notary public in and for the Commonwealth of Massachusetts, at his office No. 29 Pemberton Square, Boston, commencing 31st October, 1881; and that the same may be taken down by a short-hand writer, and his notes read to the witness; and that the signature of the witness may be made thereto by said notary, and that the deposition may be retained by defendant's counsel until the final hearing of this cause at circuit; and that the sixty-seventh rule in equity as amended shall thereby be taken to be complied with in all respects.

THOS. WM. CLARKE,
For Complainants.
J. H. RAYMOND,
For Defendant.

Boston, Mass., 31st October, 1881.

218 *Evidence for Defendant.*

Taken pursuant to stipulation.

F. F. RAYMOND, 2D,
Notary Public and Special Examiner.

BOSTON, MASS., *October* 31, 1881.

Present: Mr. Thos. Wm. Clarke, for complainant; Mr. J. H. Raymond, for defendant.

Deposition of John C. Hoadley.

Direct examination by Mr. J. H. RAYMOND, of counsel for defendant:

Int. 1. State your name, age, residence and occupation.

Ans. John C. Hoadley; sixty-two years of age at my last birthday; formerly, and for many years a resident of Lawrence, Mass., now of Boston in the same State; by profession and occupation a civil and mechanical engineer, and scientific and mechanical expert in patent causes and other causes involving mechanical and scientific questions.

Int. 2. What has been your preparation for, and what your experience in, such profession and occupation? State succinctly, but fully.

Ans. Before I was sixteen years of age I had about a year's practice in a machine shop, not as an indentured apprentice but as a learner doing the work of an advanced apprentice. In the fall and winter of 1835, being in my seventeenth year, I was employed a few months as chainman and rodman in an engineering party under J.

D. Allen, chief engineer, upon preliminary surveys for a railroad from Utica to Binghamton, in the State of New York. On the 1st of May, 1836, after a term of assiduous special study at the Utica Academy, I entered the engineering service of the State of
219 New York, under Holmes Hutchinson, chief engineer, upon preliminary surveys for the enlargement of the Erie canal, and continued steadily in such employment for almost nine years, until the very close of the year 1844, passing through every grade, except that of chief engineer, and performing the duties of every grade in preliminary surveys, location of line, making plans of structures, preparing specifications and contracts, superintending construction, and making preliminary, monthly and final estimates under Holmes Hutchinson, J. D. Allen, and Edward H. Brodhead. For about two years I was sole assistant of Edward H. Brodhead, engaged in settling the claims of contractors for work suspended under the law, and in the settlement of land damages before the canal appraisers. In the course of these nine years I was associated with many eminent engineers, Squire Wipple, O. W. Storey, William J. McAlpine and others. On the last day of the year 1844, I went to Lancaster, Mass., and took charge, as civil engineer, of the mills and factories, with their dams, canals, water and steam power, and other constructions, then recently undertaken by Erastus B. Bigelow and Horatio N. Bigelow, including the streets, houses, and public buildings of a manufacturing village afterward erected into the town of Clinton. I continued in this employment almost four years, gradually performing many duties of a mechanical engineer, under the instruction and direction of the very eminent E. B. Bigelow and his no less accomplished brother, and formed the acquaintance of many eminent machinists, inventors, and mechanical engineers, and became quite familiar with the principles of machine construction. To the steam-engine I had already devoted for many years assiduous study.

On the first day of November, 1848, the works at Lancaster being substantially finished, I went to Pittsfield, Mass., and became the partner of Gordon McKay, under the style of McKay & Hoadley, in a machine shop and foundry, employing about fifty men, manufacturing steam-engines, and making, to order, water-wheels, shafting and gearing, and a variety of general machinery.

My special duty was to design steam-engines, make plans of new machines, and to superintend the work in the shop; and I improved many opportunities to do machinist's work myself. About three and a half years later, on the thirteenth day of February, 1852,
220 I went to Lawrence, Mass., and took charge of the large establishment known as the Lawrence Machine Shop, at first as superintendent, and afterwards as agent and general manager, having charge of from twelve to twenty draftsmen, twenty or more pattern-makers and seven hundred men. The work included all the various machines for cotton-mills, woollen-mills, paper-mills and cordage factories, steam-engines, stationary, locomotive and portable, turbine and other water-wheels, printing-presses, sewing-machines, and a great variety of miscellaneous machinery. It was my duty

to understand all these machines, to write specifications and contracts, to see that the special requirements of every customer were complied with, and to make many designs and drawings with my own hands. For a thousand looms made on one order for the Pacific mills, I made three drawings, full size, of every piece; first, for the wooden pattern, to cast iron patterns from; second, for finishing the iron pattern; and third, for finishing the parts of the looms; and these looms, and 2,500 more from the same patterns, are running unchanged to this day.

In the year 1857, I began, on my own account, the manufacture of a class of portable steam-engines, of which I made and sold more than 1,300, widely scattered over the country and not unknown in other countries; and generally known in California and elsewhere as "The Hoadley." On the 13th of February, 1862, my engine business being temporarily depressed by the outbreak of the civil war, I left it in the hands of a foreman and a clerk, who on the revival of business became my partners, and went to New Bedford, Mass., and took charge as agent and general manager of the copper and yellow-metal mill of the New Bedford Copper Company, then just ready to start; and remained there until the 1st of May, 1866, when I went to Boston, and for one year took charge of the rapidly developing business of the McKay Sewing Machine Association, as agent and attorney-in-fact for Gordon McKay during his absence in Europe. While so employed, I devised and introduced the system of delivery under lease instead of conditional sale, and wrote the first lease myself; and invented and applied the recording
221 clock for indicating the work done by the several machines.

Before leaving New Bedford, I was sent, in the fall of 1863, by Gov. Andrew, to England, under a commission on his staff, to inspect guns for sea-coast defence. In 1867, on the return of Mr. McKay, I went back to Lawrence, bought out my partners and took immediate charge of my portable-engine business.

In the fall of 1877, I began the regular practice of my present profession, having occasionally served in the capacity, particularly respecting steam-engines, during twenty years previously, and have been almost constantly employed, principally in patent cases, ever since. I have always been a student of the principles of machinery, and in designing machines have been accustomed to rely on original estimates of stresses and strength rather than upon precedent.

Int. 3. Have you had experience in the construction and operation of safety valves; and, if so, to what extent?

Ans. I have never manufactured safety valves as a separate article of merchandise, but I have almost always made the safety valves for engines of my own manufacture, and have drawn and designed a good many of various sizes and constructions.

Int. 4. Have you been accustomed to construe and explain letters patent, and have you been called on, as an expert, to compare the inventions set forth in letters patent with the state of the arts existing at the date of said inventions?

(Objected to. Construction is immaterial.)

Ans. Yes, frequently.

Int. 5. Have you read letters patent of the United States No. 58294, dated September 25, 1866, granted to George W. Richardson, for alleged improvements in safety valves; also letters patent of the United States No. 85963, dated January 19, 1869, granted to the said George W. Richardson, for further improvements in his said alleged invention, and do you understand the same?

Ans. I have read both said patents, now and formerly, and I understand the same.

Int. 6. Have you investigated the state of the arts relating to safety valves as the same existed at the date of Richardson's inven-
222 tions set forth in said patents, and compared the claims of said patents with the then existing state of the arts?

Ans. I have made such examination and comparison, especially with reference to two suits brought under the same patents by the Consolidated Safety Valve Company (the complainants in this suit) against the Crosby Steam Gage & Valve Company, in which suits I was engaged as an expert for the defendants.

Int. 7. Please state briefly the result of such examination and comparison.

Ans. I found that all the mechanical elements described as employed in both of Richardson's said patents of 1866 and 1869, to increase the lift of a safety valve directly after the first escape of steam through the slighly opened ground joint, and to insure prompt relief to the steam boiler by a decisive and sufficient opening of the safety valve, and an equally decisive closing of the safety valve when a sufficient reduction of pressure within the boiler had been produced, were elements long familiar and well known to the public, having been frequently described and represented in specifications and drawings of letters patent issued both in this country and in England, and published in Patent Office reports and in other scientific publications prior to the date of either of Richardson's said patents. I also found that the combinations of said elements set forth in Richardson's said patents, to produce the results and effects I have already mentioned in this answer, are all of them familiar combinations, often employed, and described and published in the scientific publications above mentioned. I find, however, in the specifications of said Richardson patent of 1866 the following language:

"To enable others skilled in the art to make and use my invention, I will proceed to describe its construction and operation. To the head of the common safety valve, indicated by all that portion of Fig. 2 lying within the second circle from the common centre, I add what is indicated by all that portion lying outside of the said circle, *in about the proportion shown in the figure.* A transverse vertical section of this added portion is indicated in Fig. 4 by those portions of the figure lying outside of the dotted lines *p p, p p,*
223 while all that portion lying within the dotted lines *p p, p p,* indicates a transverse vertical section of the common safety

valve alone. This increased area may be made by adding to a safety valve already in use, or by casting the whole entire.

"I terminate this addition to the head of the valve with a circular or annular flange or lip *c c*, which projects beyond the valve seat E. E., Fig. 3, and extends *slightly below its outer edge, fitting loosely around it*, and forming the circular or annular chamber D D, whose transverse section shown in the figure may be of any desirable form or size. This flange or lip *c c*, fitting *loosely around the valve seat* E E, *is separated from it by about* $\frac{1}{64}$ *of an inch for an ordinary spring or balance. For a strong spring or balance this space should be diminished, and for a weak spring or balance it should be increased, to regulate the escape of steam as required.*"

There follows a description of a modified but obviously equivalent arrangement of the parts, and a description of the mode of operation. The claim is:

"What I claim as my improvement, and desire to secure by letters patent, is a safety valve with the circular or annular flange or lip *c c constructed in the manner, or substantially in the manner, shown*, so as to operate as and for the purpose herein described."

In all cases where italics appear in the above quotations from Richardson's patent of 1866, except the lower-case reference letters, I have italicized words, sentences, or parts of sentences which appear in ordinary roman letters in the Patent Office copy, for the purpose of more distinct reference.

The words, phrases, and sentences which indicate the proportions contended for in the theory of complainant's expert in this case, are the words italicised in the above quotation, namely, "in about the proportion shown in the figure;" "slightly below its outer edge, fitting loosely around it;" "of any desirable form or size;" "fitting loosely around the valve seat E E, is separated from it by about $\frac{1}{64}$ of an inch for an ordinary spring or balance. For a strong spring or balance this space should be diminished, and for a weak spring or balance it should be increased."

224 These are all. No other indications of size or proportion are to be found in the patent.

"About the proportion shown;" "slightly below;" "fitting loosely around;" "any desirable form or size;" "separated . . . by about $\frac{1}{64}$ inch for an ordinary spring;" "for a strong spring . . . this space should be diminished;" "for a weak spring . . . it should be increased."

The organic elements of the combination to be found in Richardson's patent of 1866, among which elements the proportions which he claims as his invention are to be sought, and to be found, if to be found at all, are—

1. An annular area extending around outside of the head of a common safety valve, terminated with a circular flange or lip projecting beyond the valve seat and extending slightly below its lower edge, fitting loosely around said valve seat; or an equivalent arrangement, the valve seat extending up slightly above the lower edge of the flange or lip and fitting loosely around it.

2. A part of the valve seat extending up slightly above the lower edge of the flange or lip, and either loosely encircled by said flange or lip, or itself loosely encircling the same; all in combination with all the necessary parts of a "common" safety valve, including the valve itself, its seat, the ground joint between the valve and its seat, and suitable "load" to hold the valve firmly closed upon its seat against the required pressure of steam within the boiler, whether such load be by a spring or springs acting directly on the valve, either above or below it, or by a spring or springs acting on the valve through a lever or levers, or by a weight or weights acting on the valve either directly or through a lever or levers, either above or below the valve.

The active or functional elements of the combination to be found in said patent, resulting from the combined operation of said organic elements, are—

1. Supplementary valve area of the valve outside of the ground-joint, entirely removed from the pressure of confined steam within the boiler, so long as the valve remains firmly seated on its ground joint, but exposed to the force of impact of steam escaping through the ground joint, and to the lifting pressure of steam which has passed through the ground joint, but which has not yet escaped to the free atmosphere, being partially confined within an intermediate passage, sometimes called an expansion chamber.

2. An expansion chamber above mentioned, underneath said extended area and between said area, lip, or flange, and the valve seat outside of the ground joint, and, in a measure, within the space at the ground joint itself, between the uplifted valve and its seat; and—

3. A restricted opening between the lower edge of the flange or lip, added to the head of a common safety valve and the valve seat which encircles it, or by which it is itself encircled, well known as a "stricture," all operating in combination with the essential and suitable parts of a safety valve, as above set forth.

The operation of these functional elements in combination is as follows:

1. Steam pressure within the boiler having risen slightly above that which the load (and for simplicity, the "load" will be considered a compressed spring) is able to resist, a little steam escapes through the ground joint into the expansion chamber.

2. This escaping steam first displaces the air which previously filled the expansion chamber, and being now free on the outer side, that is, at the stricture, from all pressure save that of the atmosphere, while its pressure before its passage through the ground joint was greater, generally many times greater, it is expanded in volume in the inverse ratio of these pressures, and finding inadequate space within the expansion chamber for its enlarging volume, forces a part of its mass out through the narrow stricture into the free atmosphere.

3. In the course of the operations above described this escaping steam exerts (*a*) force of impact upon the curved surface of the flange or lip, proportioned to the product of its mass multiplied by

the square of its velocity, and (*b*) elastic force in direct proportion to the compression it undergoes relatively to the free air within the expansion chamber, by reason of the obstruction to its passage through the stricture.

226 4. These effects are slight at first, and produce what is called a "warning," or barely audible (and visible) escape of steam to the air; and if the rise of pressure which caused them ceases, or if steam is more rapidly drawn off for use, nothing further than this warning may result. But if the rise of pressure continues, both forms of auxiliary action within the expansion chamber go on increasing—the force impact by the greater mass of steam discharged through the ground-joint upon the lip, elastic force by the growing inadequacy of the stricture to release the increasing quantity of steam pressing for exit—until the combined force of the pressure within the boiler upon the valve, the force of impact of escaping steam, and the elastic force of the obstructed steam huddled within the expansion chamber by the stricture, result in a mild and beneficent explosion called a "pop," which rapidly leaves the boiler, and produces a reduction of pressure within certain predetermined limits, when, by a reversal of the above-described processes, the valve closes, promptly and decisively, with a "pop" almost as distinct as that on opening.

It is quite true, as I have found by experiment, that the combination to be found in Richardson's patent of 1866, when the parts are all proportioned according to his specifications and drawings, as nearly as the same can be made out, operates very much in the manner I have described. It is also true that a material variation in any one of the parts, without suitable variation in the other parts, destroys, or at least greatly impairs, the operation of the valve. It is further true that very great departures from all his proportions, so great that no resemblance can anywhere be traced to a single one of his proportions, may be made with results in no degree inferior to the best to be obtained by adherence to his proportions.

As to the organic elements in Richardson's combination, the first, the additional area around the valve, to be acted on by steam after but not before its escape through the ground-joint *t*, seems to have been first invented by Charles Ritchie, and is described and shown in his letters patent of Great Britain No. 12078, March 2, 1848. His claim is as follows:

"Fourthly. I claim the construction of safety valves with a
227 flange, termed a compensation flange, without regard to the manner in which such valves may be weighed, as hereinbefore particularly described and represented at Fig. 7 of the drawings hereunto annexed."

The drawing Fig. 7 is, of course, like all patent drawings, entirely general in all its proportions and dimensions, and is equally applicable by way of illustration to all valves, from the largest to the smallest, for all pressures from lowest to highest, and for all degrees of pressure reduction from least to most, according to the requirements of the case, and the skill and judgment of the mechanician and designer who should employ it. No proportions or dimensions

whatever, so long as a "compensation flange" was employed, could evade Ritchie's patent while it remained in force.

I have had safety valves constructed according to this Ritchie patent, and have experimented with them, and found them to operate very perfectly in the manner he describes. One of these Ritchie safety valves was represented by a cut published in the "Artisan," a scientific journal published in England in monthly parts, with which I was formally familiar, in the issue bearing date July 1, 1858.

This additional area beyond the ground-joint was next adopted by James Webster, to whom letters patent of Great Britain No. 1955 were issued, bearing date July 14, 1857, for certain improvements in the construction of said flange, whereby it was made adjustable; but he very properly omits all claim to the invention of the additional area itself. The language of his claim is—

"I wish to be understood that I do not limit myself to the precise details herein described and represented, as the same may be varied without departing from the nature of my invention; but I claim as my invention the methods of constructing safety valves hereinbefore described, and illustrated in the accompanying drawing."

This additional area was also adopted, in a form, in one drawing, not dissimilar to Richardson's, by William Hartley, to whom letters patent of Great Britain No. 2205, dated August 19, 1857, were granted for certain alleged improvements, but properly omitting
228 all claim to the invention of the flange or additional area. His language is—

"Thirdly, the application to safety valves of the several arrangements and combination of parts, as herein set forth."

William Naylor, to whom were granted letters patent of Great Britain No. 1830, dated July 21, 1863, also adopts this additional area, but distinctly disclaims its invention in these words:

"I wish it to be understood that I lay no claim to such recoil action, nor to the extension of the valve laterally beyond its seat." The only part of his claim which relates to this subject is in the following words:

"First, the general arrangement and construction of safety valves substantially as herein described."

Other inventors also adopted the same device, of whom I will only mention Henry Waterman, to whom letters patent of the United States No. 10243, dated November 15, 1853, were issued, and to whom a reissue on the same invention, No. 2675, was granted July 9, 1867. In the original patent Waterman makes no claim for anything in connection with the additional area of flange. His claim on this subject in his reissue patent is in the following words:

"2. I also claim the concentric rim or ledge *l l*, and the overhanging part of valve *k k*, constructed, combined, and operating in the manner and for the purpose herein set forth."

It is therefore certain that the use of additional area beyond the ground joint, in various forms and of various proportions, known as a compensation flange, rim, downward-curved lip, &c., was well

and widely known before the date of Richardson's patent of 1866, and before the earliest possible date of his invention.

The second organic element, namely:

2. A part of the valve-seat extending up slightly above the lower edge of the flange or lip, and either loosely encircled by said flange or lip, or itself loosely encircling the same, is to be found in the hereinbefore-mentioned patents of Charles Ritchie, March 2, 1848; of James Webster, July 14, 1857, and Henry Waterman, No-
229 vember 15, 1853, reissued July 9, 1867, and in an imperfect form in Hartley's patent, August 19, 1867, and in William Naylor's patent, July 21, 1863.

Of the three functional elements, namely, the additional area, the expansion chamber, and the stricture, the first is to be found in perfection in Ritchie's patent, March 2, 1848; in Webster's patent, July 14, 1857, and in Waterman's patent, November 15, 1853, and imperfectly in Hartley's and Naylor's patents; the second is to be found in perfection in Ritchie's, Webster's, and Waterman's patents, and in a certain degree in Hartley's and Naylor's patents; and the third is also to be found perfectly developed in Ritchie's, Webster's, and Waterman's patents, and to some extent in Hartley's.

In all three of these early patents, Ritchie's, Webster's, and Waterman's, the combination of these common elements is substantially the same as in Richardson's, with this sole difference; namely, that in all the three first named, dimensions and proportions are neglected or disclaimed.

On a former occasion, namely, in the years 1879 and 1880, for the purpose of suits brought under these same Richardson patents of 1866 and 1869 against the Crosby Steam Gage & Valve Company, in which I was examined as an expert witness for the defence, I made numerous experiments with safety valves constructed under my direction according to the patents, respectively, of Charles Ritchie and James Webster.

Of my experiments with the Ritchie safety valve I have already spoken in this answer.

In the construction of these valves I did not attempt a servile imitation of the patent drawing in either case, nor do I admit that any such imitation can in any case be required. The drawings are not said to be made according to any scale, and if assumed without authority to be of full size, they could be correct for valves of only one size to be used under one set of conditions only, while the patents are entirely general, and equally applicable to safety valves of all sizes and for use under all obtainable conditions. Yet while making such changes in size and proportion as I considered judicious, such changes as I then thought and still think perfectly warrantable
230 under the respective patents of Ritchie and Webster, I then said, in answer to cross-interrogatory 97, "That putting Mr. Webster's drawing on all fours, and taking his diagram for working drawings in violation of all precedent, his valve would even then be a practical safety valve capable of acting in the manner indicated in the question." That is answering affirmatively the question,

"Would it have relieved the boiler with a loss of only a pound and a half of pressure, or anything like that amount?"

Subsequently, and for the purposes of the defence, in this case, I have made numerous and accurate experiments with safety valves made with the utmost exactness after the patent drawings of Webster, Hartley, and of Waterman. The two first named were made by templates and patterns formed to fit the drawings made by me from tracings of Webster's and Hartley's patent drawings, and correspond with the original drawings, not only in proportion, but also in size, as well as in every detail of construction. The third, the Waterman valve, was made from a drawing originally made by me from Waterman's patent drawing, and afterward testified to by Waterman as follows: "To the best of my recollection it is a fair representation of it. I do not know that it shows the proportions as I drew them. I drew the proportions carelessly, without any reference to making them exactly as I made my valve." In this case (the Waterman) the steam-way being $1\frac{1}{16}$ in. diameter, the dimensions were all reduced about one-third, all proportions preserved, so that the valve (here produced, and marked "Defendant's Exhibit Webster Valve Fig. 3, ") is two-thirds the size of the drawing. I subjoin the actual dimensions so far as they are of any influence on the operation of the valve:

WEBSTER VALVE EXHIBIT.

Diameter of steam-way	1.15 in
Diameter of head of valve outside of ground joint	1.47 in
Diameter outside of adjustable flange	2.30 in
Diameter of ring on valve seat, encircling the flange	2.36 in

The essential areas, ratios, &c., to be deduced from those dimensions by simple calculations, are as follows:

231	Circumference of inside of ground joint	3.61 in.
	Circumference of outside of ground joint	4.62 in.
	Ratio of outside to inside di. and cir. of ground joint	1.28 to 1
	Area of circle inside of ground joint	1.03 sq. in.
	Area of circle outside of ground joint	1.7 sq. in.
	Ratio of area outside to area inside of ground joint	1.63 to 1
	Circumference of circle outside of adjustable flange	7.23 in.
	Area of circle of outside of adjustable flange	4.15 sq. in.
	Ratio of di. and cir. of flange to di. and cir. of outside of ground joint	1.57 to 1
	Ratio of di. and cir. of flange to di. and cir. of inside of ground joint	2 to 1
	Ratio of area of flange to area outside of ground joint	2.44 to 1
	Ratio of area of flange to area inside of ground joint	4.03 to 1
	Circumference of circle inside of ring on valve-seat	7.41 in.
	Circumference of middle of stricture	7.32 in.
	Width of stricture radially	.03 in.
	Area of opening at stricture when valve is seated	.22 sq. in.
	Lift of valve required to make cylindrical opening at inside of ground joint equal in area to area of stricture	.06 in.

This valve was first tried at the shop of defendant, at Fort Wayne, Ind., on the 11th October, 1881, with the lower edge or lip of flange very slightly above the plane of the upper edge of the encircling ring on valve-seat. Daylight could just be seen under it; the vertical space was certainly less than .01 in., I called it .005 in. A distinct mark was made on the valve stem when the adjustable flange was adjusted in this position.

Experiment No. 1.

The spring being set to lift at 100 pounds, the action of the valve, opening and closing, was perfect:

Pop	100 lbs
Shut up	98 "
Reduction	2 " = 2 per cent.

232 With a good fire, making steam for about 12 horse-power, the valve remained open between the decisive pop and the equally decisive closing, ten seconds. Interval between shutting and opening, nine seconds. Whole period between pops, nineteen seconds. There was sometimes a sensible "warning" before the pop; but generally the warning, which doubtless took place, was sensibly coincident with the pop. The operation of this valve was in all respects admirable. No other steam was drawn from the boiler during these experiments, or any others conducted by me, except occasionally to relieve the boiler when tests were not going on.

Experiment No. 2.

I next had the flange set .025 in. lower, so as to give .02 in. overlap:

Pop	100 lbs.
Shut up	93 "
Reduction	7 " = 7 per cent.

Experiment No. 3.

I next had the flange set .025 in. lower still, that is, .05 in. below its first position, giving .045 overlap:

Pop	100 lbs.
Shut up	99 "
Reduction	1 lb. = 1 per cent.

It was at once perceived that the adjustable flange, held by a set-screw on the valve stem, was displaced by the force of the steam beneath it; and on examination it was found to have been moved up to the original mark, or a little above.

Experiment No. 4.

Set again, and more securely screwed to its place, at .045 overlap:

Pop	101 lbs.
Shut up	83 "
Reduction	19 " = 18 per cent.

233 Experiment No. 5.

I next had it set .065 in. higher, that is, .015 higher than its original position, no overlap, but .02 opening to daylight:

Pop	100 lbs.
Shut up	99 "
Reduction	1 lb. = 1 per cent.

All these recorded operations were allowed to repeat themselves from six to ten times, and were attentively observed. There was no appearance of the "irregular and disproportionate results" spoken of by Mr. Forbes in his deposition in this case, except when the flange slipped; and his "irregular and disproportionate results" may have been due to some similar cause. Properly constructed as to size of valve stem and other parts not involved at all in any patent, and with due attention to matters of detail, this is as good a safety valve as I ever saw—as good, I believe, as can be made in the existing state of the arts to-day.

Every element and every combination of elements to be found in Richardson's patent of 1866 exists in perfection in this Webster valve, made with Chinese fidelity according to the wholly indefinite diagram No. 3 of Webster's patent drawing.

Richardson's proportions are not to be found in this Webster valve, even in caricature; we find only contrasts.

Richardson's first direction as to proportion is that the width of the additional area outside of the head of a common safety-valve must be "in about the proportion shown in the figure." It is not clear what "the proportion shown in the figure" is. If it is the proportion of the additional width radially to the diameter of "the head of a common safety valve," it will be about ..... 1 to 11

The corresponding ratio in Webster's valve ..... 1 to 1.77

If it is the proportion of the added area to the area of circle of the head of a common safety valve, as shown in figure, it will be about ..... 1 to 2.5

The corresponding ratio in Webster's valve ..... 3 to 1

If it is the proportion of the additional width
234 radially measured from the inside of ground-joint to the diameter of the inside of ground-joint itself, it will be about ..... 1 to 4

The corresponding ratio in Webster's valve ..... 1 to 2

If it be the proportion of the added area to the area of the circle inside of the ground-joint, it will be about ..... 1 to 1.2

Corresponding ratio in Webster's valve ..... 2 to 1

It therefore appears that whatever dimensions or whatever areas be taken as a basis of comparison, not one of Richardson's proportions is to be found, even approximately, in this Webster valve "Exhibit Defendant."

Richardson's next instruction is that the terminal flange or lip projecting beyond the valve-seat "extends slightly below its" (the valve-seat's) "outer edge, fitting loosely around it" (or within it).

Webster directs his flange or lip to be set anywhere, up or down, higher or lower, according to the requirements of each set of conditions. In fact, for the best operation, the flange in the Webster valve "Exhibit Defendant" requires to be set no lower than the plane of the top or ring on seat, but a little above it. At the same time, if considerable reduction of pressure is desired, it may be set a little below. As to the "fitting loosely," either around or within the ring on valve-seat, Mr. Richardson's predecessor by nine years, comes pretty near "plagiarizing" his invention. But on looking a little more closely into what Mr. Richardson means by "fitting loosely," we find the further instruction that "for an ordinary spring" this space is to be about $\frac{1}{64}$ inch; less for a "strong spring," and more "for a weak spring." This must be referred to a valve of about the size shown in his patent drawing, which is 38 per cent. larger in area at the steam-way than Webster valve "Exhibit Defendant."

But waiving this consideration, the spring of Webster valve "Exhibit Defendant" is certainly not a weak spring. As an expert skilled in the art of constructing safety valves, I pronounce it rather "strong" than weak. Its compression for 100 pounds pressure per square inch on the under side of the seated valve is .11 inch. According to Mr. Richardson's instructions, therefore, the width of the stricture should be less than $\frac{1}{64}$ of an inch. But letting it go as an "ordinary spring," and the proper width, according to Richardson, "about $\frac{1}{64}$ of an inch," I find it to be actually $\frac{1}{33}$ of an inch, or twice as great, which takes it out of the category of approximations. I have now passed in review all that Richardson has said in his patent of 1866 on the subject of proportions, and find no single one of his rules embodied by anticipation in this "Exhibit Defendant," which is copied with absolutely servile imitation from the drawings of Webster's letters patent of Great Britain, which antedates Richardson's said patent by more than nine years; yet I have found that this valve "Exhibit Defendant" operates in a faultless manner in practical working; in a manner which Richardson must be contented to emulate, but can never surpass.

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I will only add that during the period of discharge between opening and closing, the pressure in expansion chamber, both upward on the flange and downward upon the seat, was 5 pounds in the first series of experiments.

This pressure was not taken during subsequent experiments. There is no force of impact in this valve to aid in lifting the valve. This auxiliary work is done solely by elastic pressure.

On the same eleventh day of October, 1881, I experimented with "Richardson Valve Exhibit."

Experiment No. 6.

Being set to lift at 100 pounds, it warmed at 98½, popped at 100, and closed at 97. During the warning there was no sensible upward pressure in expansion chamber; but at the valve-seat there was 1¼ pounds "suction," or vacuum. During the pop, the gauge showed 35 pounds pressure upward at lip (produced in part by impact), which gradually fell to 20 pounds just before the valve suddenly closed; while the gauge showed downward pressure at the valve-seat of 15 pounds, running up as the discharge diminished and impact grew less to 17 pounds, then, just before closing, fell to 12 pounds. Suddenly dropping to 0, both above and below, at the instant after closing.

This shows, as I have always found, that Richardson's safety valve operates by the combined effect of the impact of escaping
236 steam and the elastic force of steam compressed in some degree in the expansion chamber by the obstruction to its free escape at the stricture—compression of spring for 100 lbs. = .19 in.

Experiment No. 7.

I then tried this same "Richardson Valve Exhibit" with a valve, in place of the one that came with it, having a flange of the same diameter as the one brought with it, but said flange plane on its lower side, at a height of .12 in. above the flat part of the seat around the ground-joint, so that there was no stricture whatever, the passage through the expansion chamber being of equal width throughout. This valve rose at 100 lbs., continued "blowing" without a pop of any sort for two minutes and ten seconds, the pressure going up at the rate of 14 lbs. per minute until it reached 130 lbs., when the experiment was discontinued. This experiment demonstrates that the theory of Mr. Richardson and his expert witnesses, that a stricture is necessary to the operation of his valve, is strictly true.

Experiment No. 8.

I next removed from this "Richardson Valve Exhibit" a certain adjusting ring to be found around the outside of its valve-seat, although entirely foreign to anything in either of his patents,—the patent of 1866 or the patent of 1869. On replacing the valve, which came with the said exhibit and belongs to it, with its concave, downward-curved lip, I found that the removal of the ring had considerably enlarged the stricture, which was originally formed between the inner lower edge of the lip of the outer upper corner of the said ring. Being set at 100 lbs., the valve lifted at that pressure without any pop, continued blowing with increasing violence for four and a half minutes, while the steam rose at the rate of 2⅔ lbs. per minute till it reached 110 lbs., when the experiment was terminated. The operation was not so bad as with no stricture; but the stricture, if such it may be called, was too broad for the spring and pressure, and, Richardson's proportions being uncomplied with, the valve failed to work satisfactorily.

237 Experiment No. 9.

I now revert to the Hartley safety valve, which I have said was made exactly according to Fig. 9 of Hartley's patent drawings, marked "Exhibit Hartley," and tried by me at the same place on the same eleventh day of October, 1881. Some of the principal dimensions of this valve are as follows:

Diameter of steam-way	.85 in.
Diameter outside of ground-joint	.95 in.
Diameter outside of valve-seat	1.15 in.
Diameter of flange outside of lip	1.75 in.
Diameter of exterior wall of concave channel around valve-seat at top	2.35 in.
Compression of spring for 100 lbs. pressure per sq. in. under the closed valve	.13 in.

Result of many observations:

Warns	96 lbs.
Pop	100 lbs.
Closes	94 lbs.

In expansion chamber:

	Upward.	Downward.
Warning	2 lbs. vacuum	0 lbs. pressure.
Popping	30 lbs. pressure	24 lbs pressure.
Closing	20 lbs. pressure	Not observed.
Closed	0	0

The safety valve works very well. There is a little too much reduction for usual use, but that could be rasily remedied with a little practice and slight alteration. Here are none of Richardson's proportions, and one of his elements, an old one, namely, the stricture, is quite imperfect; so that this patent, which antedates Richardson's earlier patent by more than nine years, does not quite anticipate his alleged invention of proportion between certain elements.

Experiment No. 10.

238 I finally revert to the Waterman valve, which I have already mentioned in connection with Webster's and Hartley's valves, and tested at the same place on the same eleventh day of October, 1881.

The most important dimensions of this valve, "Exhibit Waterman," are as follows:

Diameter of steamway	1.25 in.
Diameter of valve outside of ground joint	1.48 in.
Width of flat valve seat, ground joint	.115 in.
Diameter of ring around valve seat	1.85 in.
Diameter of flange around head of valve	1.85 in.
Width of stricture radially	0.
Width of flange from outside of ground joint	.185 in.
Width of flange and valve seat from inside of ground joint	.3 in.
Compression of spring for 100 lbs. pressure per square inch under closed valve	.07 in.

Pop, at	100 lbs.
Shut up at	98 "
Reduction	2 " = 2 per cent.
Pops last	11 seconds.
Valve remains closed	29 seconds.
From pop to pop	40 seconds.

Pressure in orifice in flange: Upward pressure in expansion chamber 8 pounds, falls to 3 pounds, and closes. Downward pressure in expansion chamber 22 pounds, much greater than upward at the orifice, probably on account of the position of the orifice.

The operation of this valve is very beautiful, as good as that of any valve I ever tried.

Here we obviously have a nearer approach to Richardson's proportions, but I omit the consideration of these proportions at this time. If Richardson's proportions should be found in Waterman's valve, so much the worse for Richardson, as Waterman antedates his earlier patent by almost thirteen years.

I have now examined and set forth the state of the art as required in questions 6 and 7, so far as the same relates to Richardson's
239 patent of 1866, down to the date of his said patent; and state, as the result of my examination, that every element and every combination set forth in said patents, or to be found therein on the most searching analysis, is to be found fully developed and usefully and perfectly combined and organized in operative safety valves, even to the detail of mechanical construction in old inventions published many years before his alleged invention, and described in patents which expired long ago, leaving open to the use of all men everything to be found in Richardson's said patent, save and except possibly some of his proportions. But these proportions I have discovered to be non-essential to the perfect operation of a safety valve which shall open promptly and freely at any desired limit of pressure relieve the boiler rapidly, and effectually prevent any accumulation of pressure, and close decisively and certainly upon attaining any desired degree of reduction from the lifting pressure; since all these useful qualities are to be found combined in Webster's valve, in Waterman's valve, and in Hartley's valve, more especially in the two former, and to a certain useful but less perfect degree in Hartley's valve, while said valves differ, for the most part, very widely from Richardson's in the proportion of their essential elementary parts, all of which are common to all these valves, to Webster's, to Hartley's, to Waterman's, and to Richardson's alike.

Coming now to the second patent mentioned in question 5, and referred to in question 6, and again in question 7, now under consideration, the patent, namely, granted to George W. Richardson, January 19, 1869, No. 85963, U. S. patents—

I think the nature, object, and scope of the invention set forth in said patent very clearly set forth in the following paragraphs from said patent when limited and explained as they must necessarily be limited and explained by the co-existent and antecedent state of the arts.

"My said invention relates to improvements in the invention described in letters patent granted to me and bearing date the twenty-fifth day of September, 1866, which said patented invention relates to a means for providing a more free escape for the steam than could be obtained by safety valves as constructed prior thereto, and to insure
240 the keeping of the valve open until the pressure of the steam in the boiler or generator falls below the pressure which was required to open it; the said means so patented consisting in forming the valve with a surface outside of the ground-joint for the escaping steam to act against, the said surface being surrounded by a projecting or overlapping lip, rim, or flange, leaving a narrow space for the escape of steam when the valve is opened, but which, although of greater diameter than the valve-seat, by reason of the said lap, presents a less area of opening for the escape of steam than is produced at the valve seat, so that the steam which escapes through the area between the valve and the valve-seat shall exert pressure against the said surrounding surface, and thereby not only open the valve completely, but hold it up until the pressure of the steam in the boiler falls below the pressure by which the valve was opened.

"One part of my present invention relates to a means for regulating or adjusting the area of the aperture for the escape of the steam after acting on the said surface outside of the valve-seat, so that the valve may be set to close at any desired pressure below the pressure which will open it; and this part of my invention consists in making the aperture or apertures for the escape of steam, after it has acted on the said surface outside of the valve-seat, adjustable."

I have introduced this long quotation from Richardson's patent of 1869 because it is entirely free from letters of reference, and perfectly intelligible apart from the patent drawings; and because it sets forth with remarkable clearness the nature and scope of his alleged inventions, not only as he seeks to secure them by letters patent not yet granted, but as he believes they have been secured to him by letters patent of earlier date, to which he refers as the foundation of his later improvement, and as he chooses to recite them, and does recite them, with admirable lucidity, after years of practical experience in making and selling his patented safety-valves. Limited and construed in the light of all we know of the antecedent state of the arts, I think he properly limits his invention to "a means for providing a more free escape for the steam," &c., since more than one other "means" or mechanical device for accomplishing the same object was already well known, as we have seen, in the
241 patented devices of Ritchie, Webster, Waterman, Hartley, and others. In just so far as Richardson's device was a new "means" of accomplishing this object, it was justly the subject of a patent, and this without detriment to the rights of the public, since all the old "means" were open to public use by the lapse of expired patents. Richardson accurately describes his stricture as an essential part of his device, without the use of the word "stricture," as "a narrow space for the escape of steam * * * which, although of greater diameter than the valve-seat, * * * pre-

sents a less area of opening for the escape of steam than is produced at the valve-seat."

This may be called comment on the patent of 1866, but it is intelligent and authoritative comment, binding at least on the patentee, and is exactly in accordance with my own opinion of said patent, as well as with the opinion of Mr. Forbes, an expert witness called by the complainants in this case. A narrow exterior outlet, succinctly styled a "stricture," for the final escape of steam from the annular chamber under "a projecting or overhanging lip," the width of which outlet or "stricture" is attempted to be fixed pretty definitely, in the patent of 1866, as "about $\frac{1}{64}$ of an inch for an ordinary spring," less for "a strong spring" and more for "a weak spring," with more or less "lap" of the "lip, rim, or flange" over some part of the valve-seat, either outside or inside; this, or more properly the proportions which govern the parts of this combination, is, in the deliberate opinion of Mr. Richardson, the exact scope of his original invention; and in that opinion, clearly stated by Mr. Forbes in his deposition in this case, I fully concur.

As to the "improvement" for which he asked and obtained letters patent in 1869, Mr. Richardson could not, in view of the antecedent state of the arts, justly claim as his true, original and first invention all and every "means for regulating or adjusting the area of the aperture for the escape of the steam after acting on the said surface outside of the "valve-seat;" for James Webster in Fig. 5 of his letters patent of Great Britain No. 1955, dated July 14, 1857, shows a "means of regulating the area" of such aperture, by means, namely, of an adjustable ring or piston sliding within a perforated cylinder, fully accomplished this object; while all the
242 forms of Webster's invention, shown in his Figs. 1, 3, and 4, are equivalent functional devices.

Richardson, then, must be limited by the state of the arts as disclosed in Webster's patent aforesaid.

He mentions two forms of application of his invention; one, which he calls "the preferred mode of application," and elsewhere "the simplest mode of adjusting the area of the aperture for the escape of the steam after it passes the valve-seat."

The description of this "simplest mode" is very long, occupying no less than three pages in print, with twenty-two letters of reference—from *a* to *v*—to three drawings, Figs. 1, 2, and 3.

It consists of a subsidiary passage or outlet from the annular chamber under the lip, with a regulating ring at the extremity of this subsidiary passage by means of which a larger or smaller proportion of the steam seeking exit from this annular chamber may be drawn off, so as not to pass through the true Richardson stricture at all, leaving said invariable stricture with only the remainder of such steam to discharge, and, therefore, relatively the better able to discharge it freely or with less obstruction. The necessity of some degree of obstruction at the stricture still remains, else there would be no intermediate compression, no "huddling" in the annular chamber, and no auxiliary lifting force.

This device of Richardson's is, therefore, a sort of "by-pass," quite

similar to that sometimes employed to divert a part of the exhaust steam of a locomotive or portable engine away from the exhaust pipe between the exhaust valve and the nozzle of the blast pipe, to modify the force of the blast.

As there are other ways of modifying the force of the blast, by regulating the size of the blast nozzle, so there are other ways of modifying the obstruction at the stricture of a safety valve, namely, by regulating either the width of the stricture or by regulating the extent of the overlap.

The latter is Webster's method, and it is perfectly efficient, convenient, regular, and normal in its operation, as I have shown by experiments above described.

243 Richardson briefly mentions one mode of really "adjusting the area of the aperture for the escape of the steam after it passes the valve seat," namely, by "making the ring on the valve seat, which loosely surrounds the lip, ring, or flange, in adjustable segments, so that its diameter can be increased or diminished." This, he says, would be more complicated than the mode first and fully described, which he calls the "simplest mode," and describes in three printed pages, with three drawings and twenty-two letters of reference. It does not, therefore, appear to me that this second, "more complicated" mode of application of Richardson's improvement is described in his patent of 1869 with sufficient fulness and clearness to enable any one, however well skilled in the arts connected with making safety valves, to make a safety valve according to this "more complicated" form.

I see no reason, in all that is known to me of the antecedent state of the arts, to doubt the originality of Richardson's improvement in either its "simplest" or its "more complicated" form.

Other, and different, and better forms of regulator to adjust the operation of such safety valves, with auxiliary lifting area, with annular expansion chamber, and with stricture, existed in Webster's several devices, and were the common property of the public at the date of Richardson's earliest patent. Of course Richardson cannot be allowed to re-inclose the common ground; but he is entitled to protection in the use and sale of his own inventions so far as he is the original, true, and first inventor. I do not know of anything anterior to the date of his patent of 1869, analogous to his "simplest mode" of drawing off a regulated portion of escaping steam from an annular chamber, in order to afford more or less relief to a stricture; or to his "more complicated mode" of forming a constricting ring in segments, so as to adjust the width of the stricture. These two devices are quite distinct; the one is by no means a mechanical equivalent for the other.

Both seem to me to be equally original with Richardson; the "simplest," fully developed, the "more complicated," quite embryonic.

244 Whether practicable or not in either form, I do no not know. I should think the "simplest mode" might be so embodied as to have some practical utility; but I have never seen any safety valve in the construction of which there was to be

found either the one device or the other, or any mechanical equivalent for either.

In conclusion, Richardson's patent of 1866 describes certain well-known combinations of old and well-known mechanical elements, which combinations so proportioned do produce useful but not new results, as I have demonstrated by experiments hereinbefore related in detail; and Richardson's patent of 1866 describes certain devices for accomplishing a useful purpose already perfectly accomplished by well-known devices free to public use; but neither one of said original devices of Richardson's said patent of 1869 has ever, to my knowledge, been reduced to practice or embodied in an operative safety valve, either in its exact form or by any mechanical equivalent.

Int. 8. Have you read letters patent of the United States No. 162,831, dated May 4, 1875, for improvement in lock-up safety valves; and also letters patent of the United States No. 193,411, dated July 24, 1877, for improvement in safety valves, granted to Erastus B. Kunkle, of Fort Wayne, Ind., and do you understand the same?

Ans. I have read attentively both of said patents, and I understand the same.

Int. 9. Have you seen safety valves made in accordance with said patents, or either of them, and have you made any experiments with any such safety valves?

Ans. I have never seen a complete operative safety valve made in accordance with the patent first above mentioned, so far as the concave, downward-curved lip around and outside of the head of the valve is concerned, or with any such overlapping lip as the valve and ring on the valve-seat. Nor have I ever seen safety valves with such "small annular recess," marked 3 on Fig. 1, patent No. 193,411. but I have seen safety valves manufactured by said Kunkle with spiral springs, having a disc at the upper end, with a recess in the centre for the point of an adjusting screw, and at the bottom a similar disc, with a point on its lower side to rest in a recess in the cup of the valve, having, moreover, the spring placed low down
245 in a cup formed in the valve; the peculiar adjusting screw, with its key and its lock-up apparatus for adjusting the tension of the spring to any desired pressure within the range, contemplated in the construction of the valve; and having also adjusting rings for guiding the issuing steam after its escape through the ground-joint, upward against a flange, to aid by its force of impact, and in some degree by its elastic pressure, in lifting the valve still higher from its seat, in some degree similar to the ring marked E in Fig. 1, patent drawings of patent No. 193,411. In a word, I have seen Kunkle safety valves such as the defendant in this cause usually manufactures under his said patents and sells to his customers; and also certain other safety valves more or less modified from his usual practice for the purposes of experiment, in order to bring out more clearly the function, operation, use, and effect of the several parts of said valve, separately and in combination, and for more distinct comparison of the said safety valves with the patents

of Richardson, as I have shown the same to be limited by antecedently published and recorded invention.

Int. 10. Please state, with such detail as you may think necessary, the results of your experiments with Kunkle safety valves, especially with—

Kunkle valve, "Exhibit A, No. 1,"
Kunkle valve, "Exhibit A, No. 2,"
Kunkle valve, "Exhibit A, No. 3,"
Kunkle valve, No. 4,"
Kunkle valve, "Exhibit B, No. 1,"
Kunkle valve No. 5,"
Kunkle valve, No. 6,"

and state what resemblance, if any, you discover as the result of such experiments, and of your study of complainant's patents, between said Kunkle valves, or any of them, and the inventions secured to Richardson by his two patents, namely, his patent No. 58294, dated September 25, 1866, and his patent No. 85963, dated January 19, 1869, with your reasons.

Ans. I experimented with Kunkle safety valve, "Exhibit
246 A, No. 1," at the shop of E. B. Kunkle, in Fort Wayne, Ind., on the eleventh day of October, 1881.

Experiment No. 11.

As the result of observations very often repeated with almost perfect uniformity, I ascertained that when the spring was properly adjusted as to tension by the adjusting screw, and had come to a uniform temperature, it would pop decisively at 100 pounds with little or no warning, and close with equal decision at 98½ pounds, showing a reduction of pressure of 1½ pounds = 1½ per cent.

This action was accompanied by pressures in various parts of the mechanism, and in various directions, as follows:

1. Upward, under the flange around the head of the valve, partly impact	18 lbs.
2. Downward, at the level part of valve-seat outside of the ground joint	20 "
3. Laterally, at the inside of the ring rising up from the valve-seat	5 "
4. Downward, at top of ring rising up from the valve-seat	.5 "
5. Upward, under the outer case above the valve	2 "

The pressure downward at the valve-seat, 20 pounds, being greater than the upward pressure under the lip of the valve, seems anomolous; but on this very account I scrutinized these pressures very closely, and constantly found similar effects.

This valve has no stricture, nor any mechanical equivalent for the parts which constitute the sides of the stricture in Richardson's valve. The opening at the outlet from the annular passage into which escaping steam flows from the opened ground-joint, is at least as large in area as the annular passage itself, even when the valve is seated steam-tight at the ground-joint. It is also larger, even

when the valve is seated, than the passage through the ground-joint can ever be, when opened to the utmost; and is enlarged by the very opening of the valve, in a greater degree than is the opening at the ground-joint, on account of its greater diameter, so that
247 when the valve is most widely opened and most freely discharging steam, the widely parted lips of this gaping mouth are more than twice as far apart as the ground surfaces of the valve and valve-seat.

This is, of course, inconsistent with any possible conception of a stricture, and distinctly opposed to Richardson's definition of his stricture, and to his alleged rules for proportioning it.

The spring is compressed for 100 pounds pressure .44 inch.

I also experimented at the same time and place on Kunkle valve modified, "Exhibit A, No. 2."

This is similar to "Exhibit A, No. 1," except that in this No. 2 the rising up around the ground-joint in No. 1 has been cut away. This ring served to conduct all escaping steam up, in a vertical direction, against the lip around the head of the valve. There is no part of the Richardson combination, in either of his two patents, corresponding in function to this ring.

Cutting away said ring does not enlarge the outer orifice at all. There is now no stricture, simply because no stricture existed in No. 1.

But issuing steam, guided upward in No. 1 by the ring, is left free in No. 2 by the removal of the ring, to continue on in the direction which it took in passing through the ground-joint, and so fails to act with force on the lip around the valve-head. The result of this alteration is to be seen in the following experiment:

Experiment No. 12.

Warn slightly at			98 lbs.
Blows, no audible pop, at			100 "
Blows shrill at			103, 104 "
Blows more shrill at			105 "
Blows still more shrill	106		
Blows, screams	107	10h. 48m.	A. M.
Blows, screams louder	107½	10h. 49m.	"
Blows, screams still louder	108	10h. 50m.	"

The pressure continually rising for seven or eight minutes; no reduction, but a constant rise, continual shriek, ever louder
248 as the pressure rises, but no auxiliary lifting force, or, if any, too little to be of any avail.

The steam was now shut off and the pressure blown down to 100 lbs. On again letting on steam, when the pressure fell to 102, the valve closed. Short, sudden puffs occurred now and then between 101 and 102 or 103 pounds. Now, if there was any stricture in No. 1, there was of necessity the same stricture in this No. 2, since the lips of the external orifice or passage are at the same distance apart But there is no stricture, no constriction, no relative compression

no "huddling," and consequently no action due to anything to be found in the combinations or proportions of Richardson's patents, or either of them.

The compression of the spring for 100 lbs. was .44 in.

Experiment No. 13.

I also experimented at the same place and on the same day on Kunkle valve, "Exhibit A, No. 3," also slightly modified, the modification consisting of turning away the metal of the ring rising up from the valve-seat on its outer side, so as to reduce it to a thin ring, almost sharp at its upper edge.

Pop, without sensible warning	100 lbs.
Closes	96 "

Duration of pop, eleven seconds; duration of interval of closure, nine seconds; eight pops occurred between 10h. 50 and 10h. 53 a. m., averaging about twenty-two and one-half seconds.

Of course, the frequency and duration of the pop depends on the intensity of the fire and the rapidity of steam generation.

Here, again, is no Richardson stricture, here are no Richardson proportions; yet the action is decisive and excellent. The reduction may be considered excessive in some cases; it is only 4 lbs. = 4 per cent.; but that would be easily modified if it were worth while to make such valves.

The compression of the spring for 100 lbs. pressure is .44 in.

At the same place and on the same day I also tested Kunkle valve No. 4, put in as an exhibit in this case, and marked herein.

249 Experiment No. 14.

As the result of many observations, especially of eight consecutive openings and closings ending at 11h. 26m. a. m., I ascertained that this valve, Kunkle No. 4, with a good, steady fire in the boiler, no other steam being drawn off, warned during about eight seconds at about 100 lbs., popped at 100 lbs., closed, after remaining open twelve seconds, at 98½ lbs., a reduction of 1½ lbs. = 1½ per cent., and remained closed three seconds; whole period, from one pop to another, twenty-three seconds.

This action was accompanied by pressures in various parts of the mechanism and in various directions, as follows:

1. Upward under the flange around the head of the valve, partly impact:

During the warning, pressure	.25 lbs.
Highest during full opening, pop	24 "
Just before closing	13 "
When closed	0 "

2. Downward in level part of valve-seat outside of ground joint:

During the warning, vacuum	.75 lbs.
Highest during full opening, pop	15 "
At closing, and when closed	0 "

3. Lateral pressure in ring around valve-seat:

During the warning, vacuum	.5	lbs.
Highest during full opening, pop	27	"
When about to close	11	"
Immediately before closing, vacuum	.5	"
After closing	0	"

4. Downward at top of ring around valve-seat:

During warning vacuum	1	lb.
During full opening, pop "	.25	lbs.
While closing "	1	"
When closed	0	"

250 5. Upward under the outer case above the valve:

During warning, vacuum	.25	lbs.
During full opening, pop, vacuum	4	"
When closed	0	"

The operation of this valve appears to be faultless. Compression of spring for 100 lbs. pressure = .41 in.

There is no stricture, the external opening between the flange of valve and ring on valve-seat being larger in area, even when the valve is seated, than the opening in the ground-joint ever is, and when the valve is fully opened, probably twice as large. The stricture being an essential element in Richardson's combination, this Kunkle valve No. 4 does not contain either the proportions or combinations of Richardson's patents, or either of them.

I also tried, at the same place and on the same day, Kunkle valve, "Exhibit B, No. 1."

This is a larger valve than any of the others tested on this occasion, being 2¼ inch diameter at the steam way—inner edge of ground joint. There were three springs accompanying "Exhibit B, No. 1," one of which, in its place in the valve, when I took it at this time for the purpose of testing it, having a compression of five-eighths of an inch for a pressure of 100 pounds per square inch under the closed valve.

Experiment No. 15.

With a good, steady fire in boiler, no other steam drawn off, this valve operated with perfect regularity, and relieved the boiler easily.

Warning at 101 pounds, during five seconds.
Popping at 101½ pounds, open eight seconds.
Closing at 99 pounds, remains closed three seconds.
Reduction of pressure 1½ pounds, say 1½ per ct.

251

	While warning, lbs.	While fully open, lbs.	At closing, lbs.
1. Orifice in lip of valve, showing upward pressure and impact	+3	+7	Not noted.
2. Orifice in level part of valve-seat outside of ground-joint, downward pressure	—.5	+1.25	0
3. Orifice in side of ring, showing lateral pressure	+1.5	+3	+2.5
4. Orifice in top of ring, shows downward pressure (6 times over)	0	+⅛	0
5. Orifice in case over the valve, shows suction, to aid in holding the valve open during pop	0	+3.75	0

The sign + in the foregoing table indicates pressures above atmospheric pressure. The sign — indicates vacuum, or pounds per square inch less than atmospheric pressure. The action of this valve with the spring then in it being satisfactory (my note is, good fire, fine action), I had no occasion to change the spring.

The action of this valve is quite remarkable, and will repay a little careful study.

Some of its dimensions are as follows:

Diameter of steam-way inside of ground-joint		2.25 in.
Diameter of head of valve outside of ground-joint		2.37 in.
Diameter of outside of spring socket in steam way		1.75 in.
Diameter of interior of adjustable ring		2.75 in.
Diameter of outside edge of flange on head of valve		3.33 in.
Diameter of inside of rim on under surface of flange		2.95 in.
Diameter of exterior circle of adjustable ring		3.63 in.
Diameter of screw for compressing the spring		.38 in.
Area acted on by confined steam (valve seated)	3.976	sq. in.
Area of open steam-way around spring socket	.571	"
252 Area of ground-joint (horizontal projection)	.435	"
Area of valve when open, including ground-joint	4.411	"
Area of annular space between valve-head and ring	1.528	"
Area of annular space and ground-joint	1.963	"
Area of annular space between head of valve and inside of small rim under side of flange	2.423	"
Area of annular space between valve-head and outer circle of small rim under side of flange	4.223	"
Area of flange on valve-head over all, 3.63 diam	10.349	"
Area of cross section of compression screw, .38 diam	.11	"
Area of flange net, substantially equal to its whole area, as the compression screw bears at a point of small area, say	10.3	"

Lifting effect of 7 lbs. per square inch pressure on the annular area between interior circle of ground-joint and interior circle of rim, under side of flange on valve-head, having area of 2.423 sq. in	16.961 lbs.
Lifting effect of 3.75 lbs. per sq. in. vacuum, on whole net upper surface of valve and its flange, 10.3 sq. in.	38.125 lbs.
Total auxiliary lifting force	55.086 lbs.

As this is upward pressure in pounds avoirdupois, it is to be compared with the pressure which required .625 in. compression of the spring, namely: 100 lbs. per sq. in. on an area within the ground-joint of the seated valve = 3.976 sq. in.; and 3.976 × 100 = 397.6 lbs. avoirdupois.

Now, 55.086 divided by 397.6 equals, say 0.14. But 397.6 lbs. uplift required five-eighths of an inch compression of the spring to balance it; therefore, 55.086 additional uplift will require 14 per cent. of five-eighths of an inch = .09 in. to bring the spring again to equilibrium under this increased strain, provided the pressure remains, while the valve is raised from its seat at the full pressure, 100 lbs. per sq. in., which lifted it.

This cannot be the case, since at the inner edge of the ground-
253 joint steam is discharging freeely at comparatively low pressure, and the pressure must be below 100 lbs. per sq. in. over a considerable part of the under surface of the valve. What the mean reduction of the pressure due to this cause may be, I don't know; numerous and delicate experiments would be required to determine it. I think it likely to be about the reduction which is apparent while the valve is fully open—about 1 lb. per sq. in. more than the reduction shown at the instant of closing; in this case about 2.5 lbs. per sq. in., which, applied to the area acted on, 3.976 sq. in., gives a reduction of lifting force of 3.976 × 2.5 = 9.94 lbs. avoirdupois, which, substracted from 55.086 lbs., leaves 45.046 lbs. net auxiliary lifting force.

Taking as a divisor, instead of the force at the normal 100 lbs. pressure, the actual lifting force at the observed lifting pressure = 101 lbs. = 3.976 × 101 = 401.6, or (since it comes to the same result and is more convenient) 400 lbs. avoirdupois, we have, say, 45 divided by 400 = 1.125 = 11.25 per cent.

Now, 11.25 per cent. of five-eighths of an inch is equal to .07 in., which is probably about the greatest lift of the valve from its seat during these my experiments. This would give at the inner edge of the ground-joint a cylindrical opening equal to the circumference of a circle 2.25 in di. = 7.07 in. cir., multiplied by a vertical height of .07 in., equal to .495 sq. in., certainly an ample opening.

The distance, vertically, between the flat top of the adjustable ring and the lower surface of the small rim projecting down .02 in. below the other position of the lower side of the flange around valve-head, was, during all the experiments with this valve, "Exhibit B No. 1," above detailed, .26 in., when the valve was seated; and when fully open probably, as we have seen, .07 in. more, making .33 in.

The area of the cylindrical opening at the inner circle of this ring was, while the valve was seated, $2.75 \times 3.1416 = 8.6394 \times .28$ in. = 2.419 sq. in.

The area of the cylindrical opening at the inner circle of the small rim projecting downward .02 in. below general surface of lower
254 side of flange around valve-head, valve seated, was $2.95 \times 3.1416 \times .26$ in. = 2.41 sq. in.

The openings at these two points are substantially alike. When the valve is fully open, assuming it to be raised .07 in., this opening becomes 3.03 in the former and 3.06 in the latter, or say 3.03 in both. This is 6.1 times the cylindrical opening at inner circle of ground joint when valve is raised .07 in. ($3.03 \div .495 = 6.1$); it is twice as much as the annular area around the valve-head inside of adjustable ring ($3.03 \div 1.528 = 1.99$); and this annular area of passage up from ground joint between valve-head and ring is 3.1 times as great as the cylindrical opening at the inner edge of the ground-joint ($1.528 \div .495 = 3.09$).

Here is no stricture. The passage enlarges all the way from within outward, or is fairly bell-muzzled like a blunderbuss, open-mouthed like a trumpet.

In fact, in all these Kunkle valves, there being no stricture and no overlap, the effect of increased radial distance from the axis of steam-way on the size of the area opened is precisely as if the passage had parallel sides, a level, stationary bottom, and a cover hinged at the axis of the valve. Given any opening whatever at the inner edge of ground-joint, and the opening at any other point further out, radially, will be proportioned as its radial distance from the centre. Of course this applies only to cylindrical areas between flat surfaces,

In my opinion, it is impossible to find in this valve, "Exhibit B, No. 1," any mechanical equivalent for Richardson's alleged proportions of stricture, since no stricture is to be found in it.

The important action of steam escaping through orifices in the case, in removing a part of the atmospheric pressure from the upper surface of the valve, is very interesting. I have never seen it produced in anything like an equal degree (save in experiment No. 14, p. 163), although it is a recognized force.

Experiment No. 16.

I also tried, at the same place and on the same eleventh day of October, some experiments with Kunkle valve No. 5, a 1-inch
255 valve having no regulating ring, but only a fixed ring rising up from valve-seat around the ground-joint, a flat flange without rim or lip, and a space of .11 in. vertically.

Warns at	98 lbs.
Pops at	101 "
Closes at	100 "

Prompt, perfect action; a dozen observations all alike.

I next experimented, at the same place and on the same day, with

Kunkle valve No. 6, a 1-inch valve. This valve has a flat flange around valve head, and an adjustable ring with flat upper surface around the ground joint. The space between said flange and ring, as it was when I made the experiments ending at 12h. 5 m. p. m., was .11 in., measured vertically when the valve was seated. It had, therefore, no stricture. The compression of spring for 100 lbs. per sq. in. under the valve (lifting pressure), when closed was .21 in.

Experiment No. 17.

With Kunkle valve No. 6, 1 in.:

Pops with little or no warning at	101½ lbs.
Closes promptly at	98½ "
Reduction	3 per cent. = 3 "

Tried many times.

Experiment No. 18.

I again tried this same valve, Kunkle No. 6, with its adjustable ring screwed up to within .08 in. of the under side of flange when valve was seated. There was still no approach to any stricture, but the adjustment of the parts was disarranged. Same spring and same compression as in experiment No. 17.

With a good fire, no other steam drawn from boiler, the steam pressure rose pretty steadily, being recorded each minute, and sometimes oftener, from 100 lbs. at 2h. 3m. 20sec. to 110 lbs. at 2h. 13m. 0sec., 10 lbs. rise in 9m. 40sec., about a pound per minute, when the opening became sufficient to discharge all the steam then
256 made. The fire burned down, some steam was blown off, and at 2h. 15m. 25sec. the valve closed very gently. No pop had taken place.

I then experimented with this same valve, Kunkle No. 6, 1-inch diameter, at the same time and place, with its adjustable ring screwed down to its former position, or as nearly as so as I could measure, that is, .11 opening between top of ring and bottom of flange, about as in experiment No. 17. Spring as before.

Experiment No. 1.

With 1-inch Kunkle valve No. 6.

2h. 17m. 45sec. warns at	101 lbs. per sq. in.
2h. 17m. 50sec. pops at	101½ " " " "
2h. 18m. 10sec. shuts up at	100 " " " "

Reduction, 1½ from warning.

Again, with as hot a fire as could be made, this small valve being over-tasked:

2h. 19m. 20sec. pops at	101	
2h. 20m. 0sec. continues at	102	
2h. 21m. 0sec. " "	103	Fire very hot.
2h. 22m. 0sec. " "	103½	" " "
2h. 23m. 0sec. " "	103½	" " "
2h. 24m. 0sec. shuts up at	100	

Office Supreme Court U. S.
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JAMES H. McKENNEY.
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SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1885.

CONSOLIDATED SAFETY VALVE COMPANY,
vs.
ERASTUS B. KUNKLE.

Appeal from Northern District of Illinois.

IN OPPOSITION TO THE MOTION TO ADVANCE THIS CAUSE UPON THE DOCKET,

Appellee states:

1. The only reason alleged for advancing the cause is, that it "probably can not be reached in its order before the expiration "of the complainant's patents," and that the Court below, having found that said patents were not infringed, and more recently, and since the decision of this Court in "the Crosby case" at its last term, the Circuit Court for the District of Indiana having denied a motion for an injunction, appellants "have failed to "obtain preventive relief against the defendants, and are likely "to fail unless the cause be advanced."

This is not sufficient cause, the reasons stated not presenting any equity, for it has been judicially determined, and, until in the regular course of procedure it be otherwise determined by this Court, it is *res adjudicata* that appellant has no equity against appellee.

2. If the pronouncement of this Court at the last term concerning the two patents involved is correctly understood, then *upon the exact construction thus given to these patents* the Circuit Court for the Northern District of Illinois has determined that this bill should be dismissed.

3. The motion has for its sole object and basis the obtaining, if possible, of an injunction below under a mandate. Appellant's principal patent expired more than two years ago. The

other patent sued upon is for certain details of construction, is a secondary patent, and will expire January 19th next. If the cause should be advanced to any practicable date, and especially if reasonable time be given appellee to prepare for the hearing, sufficient time will not remain for the usual and due consideration of the case by this Court and also for such other proceedings as are necessary to accomplish the object sought by appellant, even if the decree below should be overruled as to said secondary patent.

4. Relying upon the regular course of procedure in this Court, and upon its explicit rules in this regard, appellee's brief has not yet been prepared, other and pressing duties of a professional character, and continuing even during the summer months, having prevented.

5. Paragraph 7, rule 25 of this Court, provides that, excepting criminal cases, cases which have once been adjudged by this Court upon the merits and cases of general public interest in which the United States are concerned, "No other case will be "taken up out of the order on the docket or be set down for "any particular day, except upon *special and peculiar circum-* "*stances* to be shown to the Court."

In *Sage* vs. *R. R. Co.*, 93 U. S. 412, the Chief Justice said, "Both the appellants and the appellees ask to have the cause ad- "vanced for a hearing, but as only private interests are involved, "we see no reason why it should have preference over other suits "upon the docket." And see 11 *How.* 528; 12 *Otto* 159; 13 *Otto* 521.

6. The aid of this court should not be asked solely for the purpose named in the motion.

The motion is opposed by appellee (1) because, as this cause stands, appellant has no equity against appellee calling for an unusual order by this court; (2) the finding below that the bill should be dismissed was in accordance with the opinion of this court, at the last term, concerning said patents; (3) if the cause

be advanced, still sufficient time does not remain to accomplish the purpose of the motion; (4) to advance the cause would be in opposition to the explicit rules of this court and in derrogation of the rights of other parties, and (5) the appellee is entitled to and desires the time afforded by the regular course of procedure within which to prepare to properly submit the case.

Respectfully submitted.

JAMES H. RAYMOND,

Chicago, Oct. 13, 1885. *For Appellee.*

119-45

SUPREME COURT OF THE UNITED STATES.

THE CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

APPEAL FROM THE NORTHERN DISTRICT OF ILLINOIS.

APPELLANT'S BRIEF.

THOS: WM: CLARKE,
29 PEMBERTON SQ., BOSTON,
of Counsel.

Supreme Court of the United States.

THE CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

APPEAL FROM THE NORTHERN DISTRICT OF ILLINOIS.

STATEMENT.

This was a bill in equity, brought to restrain infringement of two Letters Patent, both embodied in the same manufactured article.

The patents were granted to George W. Richardson for improvement in safety-valves, and are No. 58,294, of September 25, 1866, and No. 85,963, of January 19, 1869.

These patents were set up, No. 58,294, in the original bill (*R.* pp. 2, 3), filed October 6, 1880, and No. 85,963, in an amendment filed November 15, 1880 (*R.* pp. 6, 7).

By the same amendment the Ashcroft patent No. 81,863 was set up (*R.* p. 6), but no evidence was taken upon it.

Replication was filed January 27, 1881 (*R.* p. 11).

stricture of the Richardson patent of 1866, because Richardson requires the *area of opening of the stricture to be less than the area of opening at the ground-joint when the valve is lifted*, and the Kunkle valve is not so constructed (*R.* pp. 20, 21, * 44, 45).

3. That the Richardson patent of 1869 was not infringed, because Webster had shown, in 1857, a means of adjusting a stricture in his valve by a sliding-plate and set-screw, and therefore Richardson could only patent in 1869 the regulating device of *a screw-ring as applied to the secondary stricture of his valve*, and Kunkle's use of the regulating screw-ring was not the same thing (*R.* pp. 21, 22).

4. That Richardson's advance in the arts was due to mechanical skill merely, and not to invention (*ibid.*).

Each of these propositions is erroneous.

1. The Richardson patent of 1866 is entitled to the construction given in the Supreme Court opinion which overruled Judge LOWELL.

2. The opening at the *valve-seat* of the Richardson patent of 1866, to which the size of the stricture is said to have relation, is *not at the ground-joint, but in the huddling chamber*, by the express words of the patent. And hence the verbal as well as mechanical relation of the stricture is with the height or vertical area of the huddling chamber on any circumference, and not with the ground-joint.

3. The construction given by the Supreme Court to the Richardson patent of 1869 must prevail.

4. The Richardson valve marks an epoch in steam

engineering, and is not merely an antecedent valve more nicely finished.

BRIEF.

This case starts from the standpoint of the Crosby case.

All the evidence before the Court in that case was admitted into this by stipulation; and the result of that evidence, as stated by the Supreme Court in *Consolidated Safety Valve Co.* v. *Crosby Steam Gage & Valve Co.*, 113 U.S. 157, must govern, on the construction of the patents, the result in this, unless additional things are put in evidence to modify the scope of the patents.

THE CASE HAS NO NEW FACTS: IT HAS NEW DISCUSSIONS.

Discussions and arguments about the things in evidence in the Crosby case will not change the interpretation of the patents, especially if they are conducted by the same persons as in that case.

The oral testimony in this case is given by two experts, C. W. Forbes for complainant, and J. C. Hoadley for defendant.

Mr. Forbes was the complainant's rebutting expert in the Crosby case, taking up the case on the death of Mr. Hervey Waters, and Mr. J. C. Hoadley was defendant's expert in the Crosby case.

Every patent relied on or in evidence in this case was referred to in the Crosby case; and every valve described in a patent, relative to which experiments

were made in this case, had a representative, more or less similar to the one put in in this case, put in and worked in the Crosby case.

Every one of the patents referred to in the opinion of the Court below in this case, as controlling the construction of the Richardson patents, was weighed and found wanting in controlling power in the Crosby case.

On the question of construction of the patents, one half of the line of Plautus surely applies to the Court and the defendant:

"*Rem actam agis.*"

I will not apply the rest of this couplet to either defendant or his counsel.

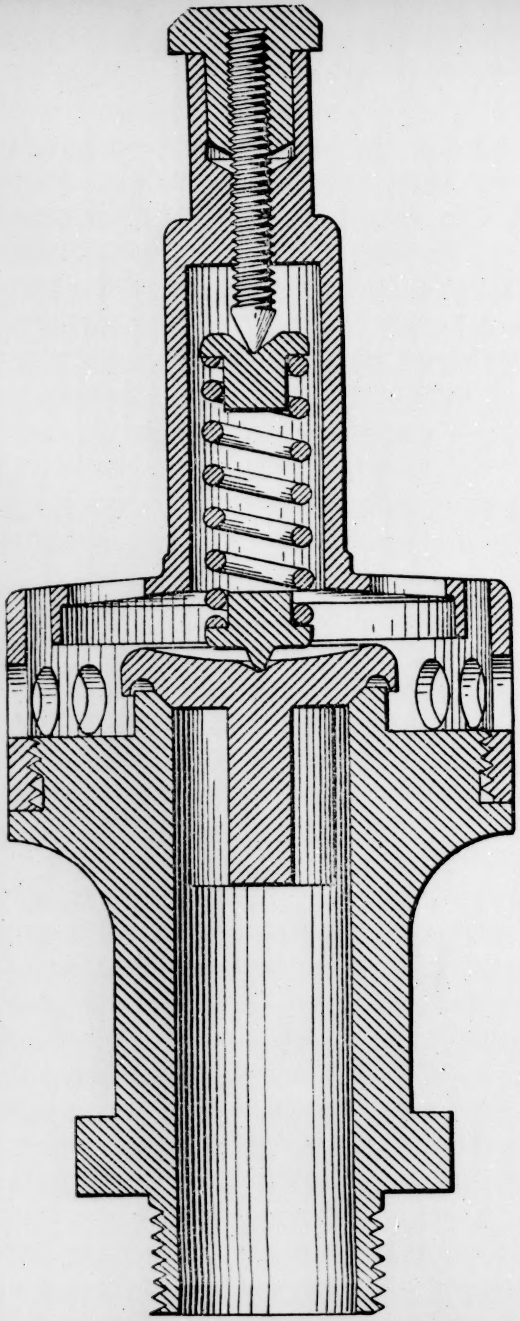
Discussion of the state of the art therefore will be a presentation of new arguments, or old arguments in a new dress, about old facts and old things. New discoveries of the capacities of old things, made since 1880, are not thought to disclose the known capacities of those things before 1870.

NEW SUBJECT MATTER.

Two new defences appear; one arising out of the subject matter pursued.

The Kunkle valves differ in form from the Crosby, hence the question of infringement is new.

An attack is made on the Richardson patent of 1866, in evidence, as insufficient and misleading.

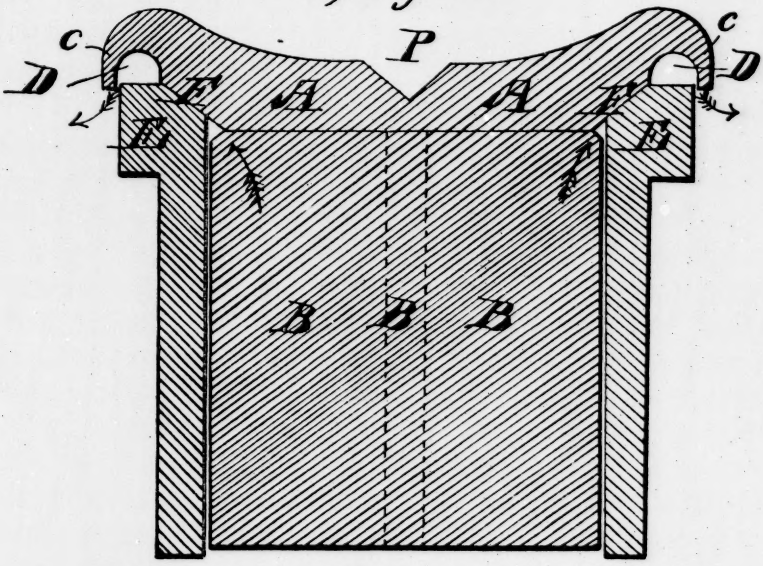


Defendants Exhibit Richardson Patent
1856 A (introduced p 201*235)

THE RICHARDSON PATENT OF 1866 SUFFICIENT AND NOT MISLEADING.

The illustration of the Richardson patent of 1866, full size, is here given to show what Richardson was describing.

Fig: 3.



Richardson Valve of 1866, *from the Patent Drawings.*

The valve from which experiments were made, on which the criticism of insufficiency is founded, is marked "Defendant's Exhibit Richardson Patent of 1866, A," and is represented opposite in full-size section. The patent showed a 24″ valve, the exhibit a small inch valve (.99″).

The measures of these valves are given (*R.* p. 204), by which it appears that for $\frac{1}{5}$ of the lifting area, and $\frac{1}{5}$ of the additional area, there was provided a huddling chamber of less than $\frac{1}{15}$ the size, and a stricture of $\frac{11}{25}$ the area, and a spring of the same proportionate tension.

Defendants made their reduction exactly *proportional by linear dimensions.* Now a reduction by linear dimensions controls the size of the stricture, but the expansion of the steam, which the stricture is to control, is regulated to some degree by the size of the huddling chamber, and this size is the cube of linear dimensions.

Thus if linear dimensions are as 2.25 : 1, the size of the huddling chamber will be as 125 : 8, or as 15.6 : 1.

So that the two ratios which had co-relation, that of steam-room and that of stricture, were as follows:

Richardson's steam-room in the drawing : steam-room in the "Defendant's Exhibit Richardson Patent, 1866, A" :: 100 : 6.3. Richardson's stricture in the drawings : stricture in the "Defendant's Exhibit Richardson Patent, 1866, A" :: 100 : 44.

Error in size of steam-room, $600\frac{0}{0}$ *of present size.*

The reduction of pressure given by this exhibit was excessive, varying from 15.9 per cent with a $\frac{1}{8}''$ spring to 38.2 per cent with a $\frac{3}{8}''$ spring (*R.* pp. 206, 207).

The valve made exactly according to the measurements of the patent, "Complainant's Exhibit Rich-

ardson Patent of 1866," gave a reduction varying from 2 per cent with a $\frac{1}{4}''$ spring to 4 per cent with a $\frac{3}{8}''$ spring (*R.* p. 209).

And defendant's expert, Mr. Hoadley, admits that when the Richardson proportions and directions are followed, good results can be reached, but that "a material variation in any one of the parts, without suitable variation in other parts, destroys, or at least greatly impairs, the operation of the valve" (*R.* p. 117).

"*TIMEO DANAOS ET DONA FERENTES.*"

And he produces the criticised exhibit "purporting to represent" the Richardson 1866 valve (*R.* p. 201) as a thing "made with intelligent fidelity" (*R.* p. 205), with an endeavor to overcome the "spirit presumably adverse," using a "friendly application of skill and knowledge," and a "friendly discretion favorable to the working of the valve" (*R.* p. 206).

With all this "taffy," he fails to say the one essential thing, that the exhibit fairly and fully represents the device of the patent in its operative features, and all its operative features on a reduced scale. And we have seen it does not.

Complainants therefore pray a judgment that the Richardson patent of 1866 is sufficient and not misleading.

INFRINGEMENT OF RICHARDSON PATENT OF 1866.

This question depends largely on the construction of the patent.

Defendant's contention is that the Richardson patent of 1866 prescribes that the opening at the stricture shall be smaller than that at the "ground-joint" when the valve lifts (*Judge Blodgett's opinion*, *R.* p. 21; *Hoadley's evidence*, *R.* p. 185).

This contention originates from words in the patent of 1869, which state in set terms that the means of the patent of 1866 (*R.* pp. 66, * 137) "consisted in forming the valve with a surface *outside of the ground-joint* for the escaping steam to act against, the said surface being surrounded by a projecting or overlapping lip, rim or flange, leaving a narrow space for the escape of steam when the valve is opened, but which, although of *greater diameter than the valve-seat*, by reason of said lap, *presents a less opening* for the escape of steam *than is produced at the valve-seat*" (p. 66).

This description is reproduced in other language later in the patent (*R.* p. 68).

It is assumed by defendants that the terms "valve-seat" and "ground-joint" are synonymous. And they often are in common parlance; and unless the patent of 1869 or that of 1866, or both, discriminated and distinguished them, the argument would have force.

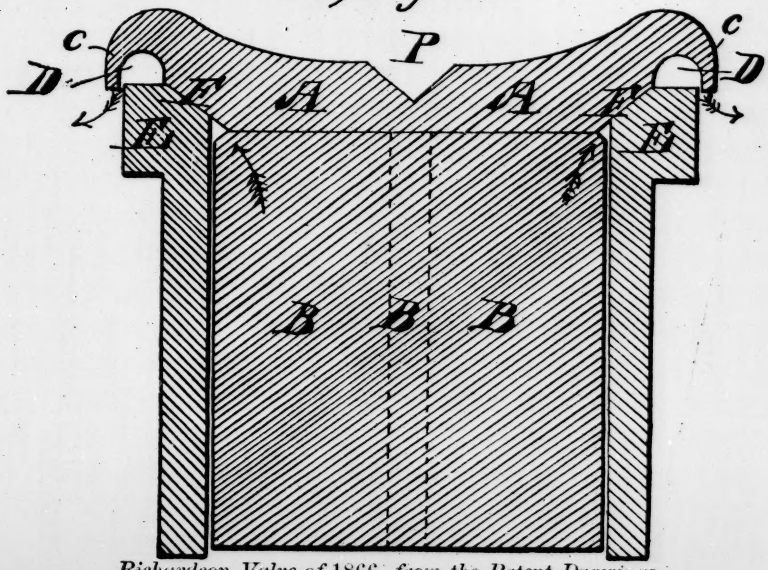
But the "valve-seat" is more than the "ground-joint;" for the lower surface of the "ground-joint" is called in the patent of 1869 "*the bevel of the valve-seat*" (*R.* p. 68, * 142), and later the "bevelled ground-joint" is spoken of, and the "*valve-seat*"

is described as "having a flat annular surface *beyond the bevel;*" and the flange on the valve is spoken of as coming down below "the plane of the surface of the valve-seat," and the stricture is described as existing "between the inner periphery of the said flange and the outer periphery of the valve-seat" (*R.* p. 69, * 143).

In only one place in the patent of 1869 is the word "seat" used so as to imply the "ground-joint" merely (*R.* p. 67, * 139, 140), — "bevelled seat," — and even in this instance it has a qualifying word.

In this patent of 1869, from which the argument for the identity of "ground-joint" and "valve-seat" is drawn, the distinction is perfectly marked, but when we turn to the patent of 1866 we find the two things very broadly discriminated.

Fig: 3.



Richardson Valve of 1866, *from the Patent Drawings.*

In the description with reference to the drawings (*R.* p. 64, *133, 134), "E E is the valve-seat, F F is the *ground-joint of the valve and seat.*" The lifting of the valve is said to be "from its seat *at the ground-joint.*"

That there may be no doubt that the whole top of the bush was the valve-seat, Richardson says (*R.* p. 65, *135), "the flange or lip *c c* . . . projects *beyond the valve-seat* E E and *extends slightly below its outer edge, fitting loosely around it.*"

That there might be no doubt as to the part called the "valve-seat," which co-operates with the steam in raising the valve, and at which the area of opening produced by raising the valve is referred to the area of the stricture, he further says (*R.* p. 65), "and by this means, together with the reaction produced by being thrown downwards upon the valve-seat E E, it [the steam] overcomes the rapidly increasing resistance of the spring or balance."

From this examination of the words of the patent it is clear that the relation of the area of the stricture spoken of, is an operative relation to any area between the valve and the seat outside of the ground-joint, or, in other words, to the transverse area of the "huddling chamber" on any diameter within it, and not a casual relation between the stricture and the opening at the ground-joint; exactly as stated by Mr. Forbes in the last answer of his last deposition. "Cross-int. 14: If in a spring safety-valve the size of the opening at the ground-joint be less than the

size of the opening through which the steam escapes to the valve-case or the atmosphere, but the size of the intermediate chamber be greater than the size of said opening to the case or the atmosphere, a stricture is thereby created within the meaning of the Richardson patent of 1866: am I correct?

"*Ans.* Most certainly correct, sir" (*R.* p. 223).

ALLEGED ANTICIPATION.

At this point the defence of anticipation may well be considered.

The patents relied on by defendants were those to Webster and Hartley in England, and the American patent to Waterman.

They were all considered in the Crosby case.

This Court said (113 U.S. 170–172):

"In the present case the defendant has introduced in evidence the before-named English patents to Ritchie, Webster and Hartley, and the English patent to William Naylor, No. 1830, granted July 21, 1863; and also Letters Patent of the United States, No. 10,243, granted to Henry Waterman, November 15, 1853, and the reissue of the same, No. 2675, granted to him July 9, 1867. In view of all these patents, and of the state of the art, it appears that Richardson was the first person who described and introduced into use a safety-valve which, while it automatically relieved the pressure of steam in the boiler, did not, in effecting that result, reduce the pressure to such an extent as to make the use of the relieving apparatus practically impossible, because of the expenditure of time and fuel necessary to bring up the steam again to the proper working standard. His valve, while it

automatically gives relief before the pressure becomes dangerously great, according to the point at which the valve is set to blow off, operates so as to automatically arrest with promptness the reduction of pressure when the boiler is relieved. His patent of 1866 gave a moderate range of pressure, as the result of the proportions there specified, and his patent of 1869 furnished a means of regulating that range of pressure by a screw-ring within those narrow limits which are essential in the use of so subtle an agent as steam.

"In regard to all of the above patents, adduced against Richardson's patent of 1866, it may be generally said that they never were in their day and before the date of that patent, or of Richardson's invention, known or recognized as producing any such result as his apparatus of that patent produces, as above defined. Likenesses in them in physical structure to the apparatus of Richardson in important particulars may be pointed out, but it is only as the anatomy of a corpse resembles that of the living being. The prior structures never effected the kind of result attained by Richardson's apparatus, because they lacked the thing which gave success. They did not have the retarding stricture which gave the lifting opportunity to the huddled steam, combined with the quick falling of the valve after relief had come. *Taught by Richardson, and by the use of his apparatus, it is not difficult for skilled mechanics to take the prior structures and so arrange and use them as to produce more or less of the beneficial results first made known by Richardson;* but, prior *to* 1866, *though these old patents and their descriptions were accessible, no valve was made producing any such results.* Richardson's patent of 1866 states that the addition to the head of the valve terminates in an annular lip, which fits loosely around the valve-seat, and is separated from it by about one sixty-fourth of an inch for an ordinary spring,

and a less space for a strong spring, and a greater space for a weak spring, forming an annular chamber and regulating the escape of the steam; that the steam, when the valve is lifted, passes beyond the valve-seat and into the annular chamber, and acts against the increased surface of the valve-head, and thus overcomes the increasing resistance of the spring, due to its compression, and lifts the valve higher, and the steam escapes freely into the open air, until the pressure is sufficiently reduced, when the spring immediately closes the valve. It is not shown that before 1866 any known valve produced this result. On the contrary, Richardson testifies that for about twenty years before 1866 he was acquainted with safety-valves in practical use, by working in the locomotive repair-shops of railroad companies, part of the time as foreman, and as a locomotive engineer, and that he never, before his invention, knew, in practical use or on sale, of any spring-loaded safety-valve capable of opening to relieve the boiler when the working pressure was exceeded, and of automatically closing with a small loss of working pressure. He also says that he was in England for about four months in 1873, bringing his valve to the notice of officials in the shops of some of the largest railroad companies (his valve be ng one especially useful on locomotive engines on railroads); that while he was in England he found no man who professed to be acquainted with, or to have heard of, a safety-valve which would automatically open and relieve the boiler at a predetermined working pressure, and automatically close when such working pressure had been slightly reduced, or who admitted that such a valve could be made, until he had seen Richardson's valve work; that the master mechanics at the shops named did not believe he could make a valve close with 25 pounds of the blowing-off point; that he showed them the working of his valve with no excess

beyond working pressure, and with but 3 to 5 pounds' reduction from a pressure of 130 pounds per square inch in the boiler; that he did not hear in England of any of the Ritchie, Webster or Hartley valves, but heard the Naylor valve blow; and that when it blew the steam rose several pounds above the point where it commenced to blow, and it did not close promptly, tightly or suddenly. There is no evidence to contradict or vary the effect of this testimony."

THE SCOPE OF AN INVENTION, AND HOW TO ASCERTAIN IT.

The vital proposition of the patent law, its only justification in a commercial community, is the proposition that it will promote science, and advance the useful arts, if inventors have, for limited periods regulated by law, the exclusive right to profit by their discoveries under their own management, on condition, that when a discovery is made, the best description the inventor can give of its nature and scope shall be made a public official document of state with reasonable speed.

The nature and amount of the advance in the arts involved in the discovery is always a question of fact in which there are two inquiries, one of which is, what is the aggregate result produced by the new publication, the other of which cannot exceed the aggregate result of all preceding publications and work at the time of the discovery newly published.

This last factor, to speak as an arithmetician, cannot be multiplied by any human knowledge acquired

after the publication of the discovery to increase the minuend.

If written descriptions and drawings are to be followed, they are to be followed without grave departures, and as nearly as a competent mechanic of the day of their publication would follow them, with the spirit of a disciple of the writer, not of a Port Royalist citing St. Augustine, or of Corporal Trim reading ing the text from St. Paul.

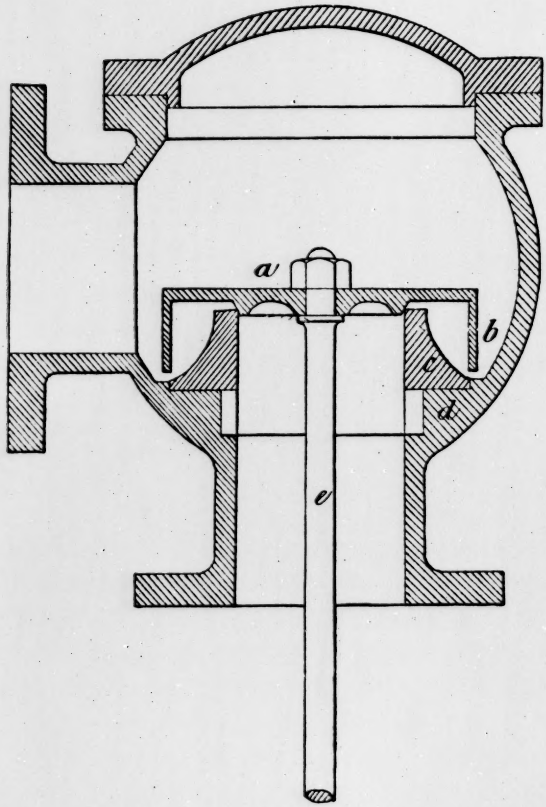
Strength may be added, but operative shapes and constructive features must not be changed.

With these conditions of investigation, let us compare the defendant's work in this case on the question of anticipation, with the instructions given by the publishers of the documents on which the defendant's work purports to be based, and see if the work is the work of a disciple of Webster, Hartley or Waterman, or of a disciple of Richardson, who denies his master.

THE HARTLEY VALVES.

Hartley illustrates his valve as follows: he says it is loaded with a weight (*R.* p. 50).

FIG. 9.



The Hartley valve from the Patent Drawing.

Defendant loads his so-called Hartley valve with a strong spring about $\frac{1}{8}''$ compression (.13″), and gives a different curve to the walls of the huddling chamber and the exhaust from the huddling chamber.

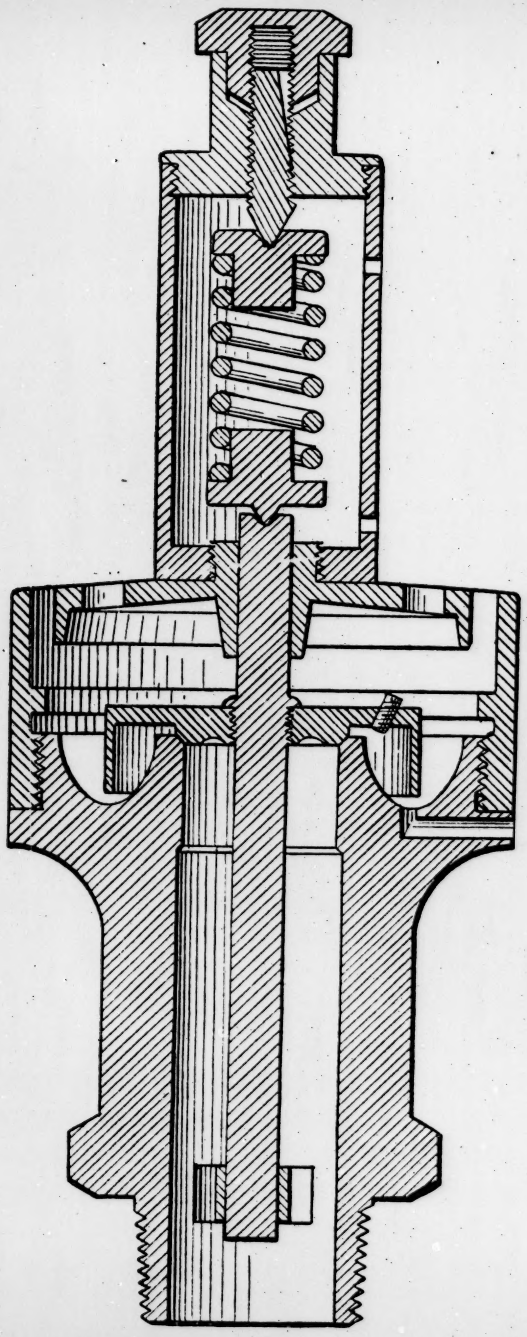


Exhibit Hartley introduced by Defendants, p 125 + 237.

This embodiment is shown opposite the drawing from the patent.

Even thus travested, it was not a practical valve (*R.* p. 125). Mr. Forbes says (*R.* p. 220), and Mr. Hoadley concedes (*R.* pp. 148, 149), that Mr. Hoadley first learned how to make this valve, as he did make it, from experiments in the Crosby case in 1880. Forbes says it does not represent the invention, and besides is ineffective (*R.* p. 220).

THE WATERMAN VALVE.

The Waterman reissue is in evidence only as part of the Crosby case. The original patent to Waterman is in evidence (*R.* p. 62), and a valve purporting to be made "with the utmost exactness after the patent drawing" (p. 120) was put in evidence (*R.* pp. 125, 159).

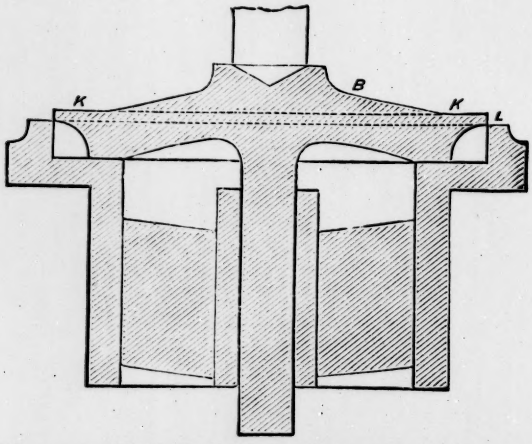
The criticism of this Court upon the announcement that Waterman had invented anything before Richardson, in the same direction as Richardson, is here worth remembering.

"The original patent to Waterman was issued in 1853. His attention had been turned to the subject of safety-valves for locomotive engines. He invented what he described in that patent, but he testifies that, *before* 1866, *he never saw a safety-valve capable of keeping the pressure at a point not above working pressure, and of relieving the boiler with but a small loss of pressure; that his valve would let the steam down about fifteen pounds, and was not practical for an ordinary locomotive;* and that the Richardson valve, when introduced, went at once into general use. The Waterman

valve had a supplemental surface on which the steam acted to aid in the raising of the valve; and this was shown in the drawing of Waterman's original patent, but the specification did not describe it. *Waterman's original patent did not show the use of a spring, and prior to its reissue his valve had not been made with a spring.* After Richardson obtained his patent of 1866, and Waterman knew of Richardson's valve, they combined the interests in their two patents, and the reissue of Waterman's was obtained, with the co-operation of Richardson, he signing as a witness the specification of the reissue. That specification, granted in 1867, describes an overhanging part of the valve as increasing its area outside of, and beyond, the ground-joint, and a concentric rim or ledge, which directs the steam upward against such overhanging part of the valve, so that the valve is assisted in rising. The specification was drawn in view of Richardson's patent and valve, and for the purpose of making a claim, which was then made, and which was not in Waterman's original patent, to a combination of the concentric rim or ledge with the overhanging part of the valve. The specification states that the valve and its seat are so constructed that the escaping steam will act on an increased area of the valve after it has risen from its seat, and strike the overhanging or projecting annular surface above, and outside of, and beyond, the ground-joint. It also states that a proper modification of the overhanging or projecting annular surface will modify the force of the steam; that if such surface be large, the valve will be opened suddenly and discharge so much steam that the pressure in the boiler will be considerably reduced before the valve closes; that such surface may be made so small that but little more than the surplus steam will escape; that the success or efficiency of the valve will depend on a proper proportion between the overhanging

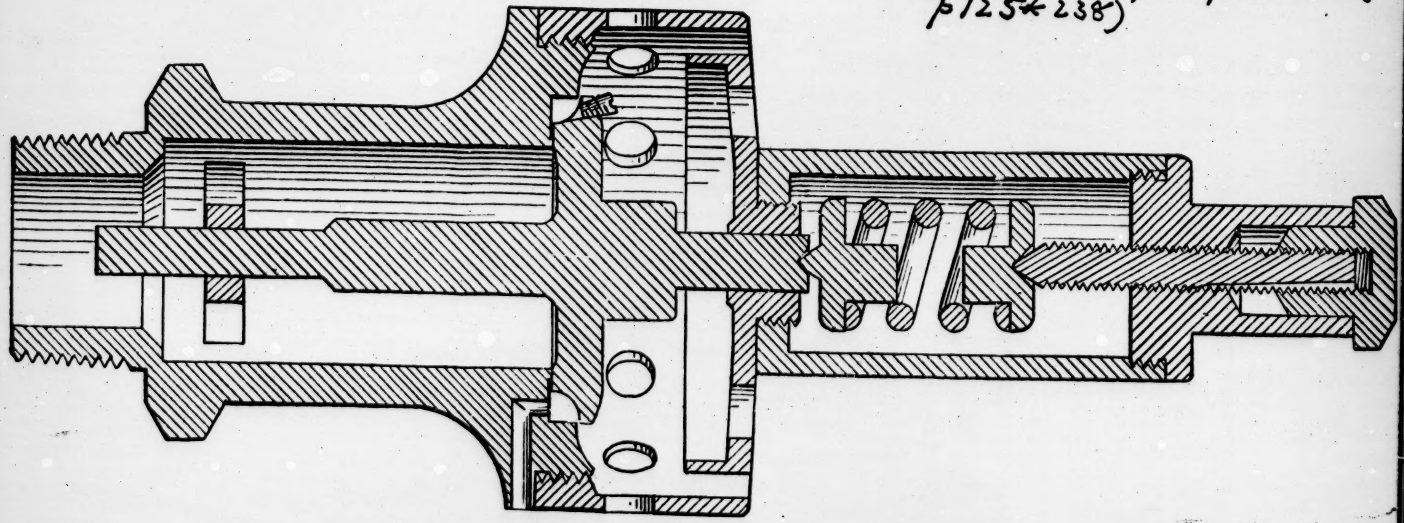
annular surface and the concentric rim or ledge, because, if a free discharge of steam between them is allowed, the valve will not be assisted in rising, and if the escape of steam is too small, the valve will rise too easily, and remain open too long, and the steam will be so much reduced in pressure as seriously to impair the economical and efficient action of the apparatus; and directions are given as to the sizes of the overhanging part, and of the ledge or rim, and of the opening, for a valve of a specified diameter, acting with a specified pressure of steam. Nothing of all this was found in the specification of the original Waterman patent. It therefore has no effect, as against Richardson's patent of 1866, to destroy the validity of that patent" (113 U.S. 175).

The defendant's contention as to Waterman's anticipation is, in this case, based on the action of a valve which resembles the valve of the Waterman patent drawing even less than the Hartley exhibit does the Hartley drawing.



Waterman Valve from Crosby Record, p. 417, C. Ct., and on smaller scale, p. 322, S.C.

Exhibit Waterman
(Introduced by Drefs
p 120 ← 280, Experiments
p 125 ← 238)



The weight and dash-pot of the patent are dispensed with, and a spring of .07 compression substituted (about $\frac{1}{1}$″).

An open stricture, not shown at all in plate 4 (*R.* p. 62), nor in the accompanying enlarged drawing of the patent, was introduced; and the statement is made that this stricture *has no radial width* (*R.* p. 125), *without any suggestion that it has vertical width.*

The patent drawing and the defendant's attempt to reproduce it are represented opposite each other on the preceding pages.

THE WEBSTER VALVE.

The Court in the Crosby case said this (113 U.S. 174):

"Ritchie gives no information how to make a valve work at a predetermined pressure, or how to make it work with a small range of difference between the opening and closing pressures, or how to proportion the strength of the spring and the size of the stricture to each other. The same thing is true of the Webster and the Hartley patents.

"The Webster patent shows a huddling chamber and a stricture. *But the evidence shows that valves made with the proportions shown in the drawings of Webster work with so large a loss of boiler pressure, before closing, as to be practically and economically worthless.* Webster's patent describes a means of making the area for the escape of steam adjustable, consisting in adjusting up and down, on a smooth valve-stem, a sliding collar or flange, and fixing it in place by a

set-screw. But it does not show the screw-ring of Richardson with its minute delicacy of adjustment and action."

As great stress had been laid in the argument in Massachusetts on the fact above italicised, it was thought of consequence, in 1881, when this case was at rules, for defendant to try to control this proof by a re-arrangement of parts in an exhibit.

In considering this evidence, one must bear in mind Mr. Hoadley's statement that "a material variation in any one of the parts without suitable variation in other parts destroys, or at least greatly impairs, the operation of the valve" (*R.* p. 117).

He must also bear in mind Mr. Forbes' statement (*R.* p. 42) that there are four things which contribute to the working of an automatic safety-valve: (1) the spring; (2) the ratio of the extended surface to the initial surface; (3) the size of the chamber beneath the supplemental surface, and (4) the size of the stricture; that the spring is difficult to regulate in itself, and also exceedingly difficult to make of any determinate degree of tension; that the ratio of one surface to another is also a thing difficult to change in any given metallic valve, and that the size of the chamber is also difficult to change, and does not give delicacy or precision of adjustment by its alteration; and that the stricture is a thing easy of adjustment and produces considerable effects. The problem which defendant's expert set himself to solve was to produce apparent similarity by manipulating the spring.

He was to retain Webster's proportions of areas and his size of huddling chamber, which Hoadley had already *denounced as lunatic* (*R.* p. 152, cross-int. 84), in 1880, and to rely on spring alone, the most unmanageable element of all, to get seeming conformity to proper action.

THE HOADLEY EXPERIMENTS DECEPTIVE.

He used for tests a steam apparatus in which steam could be raised from 41 pounds pressure to 100 pounds pressure in from $7\frac{1}{2}$ to $7\frac{3}{4}$ minutes (*R.* p. 166), instead of the ordinary boiler, requiring, according to Adams' testimony in the Crosby case, at the rate of one minute for every two pounds pressure, besides the time required to heat the feed water, 10 or 12 minutes more, — some 40 minutes in all.*

Yet this singular steam supply which could raise the steam pressure from 41 to 100 pounds at the rate

* NOTE. — The following is from Adams' testimony, p. 291, Supreme Court record, in *Consolidated Safety Valve Co.* v. *Crosby Steam Gage & Valve Co.*: —

"A good boiler with a natural draught will generate steam from 44 to 100 pounds at the mean rate of 2 pounds per minute of time; and $\frac{56}{2}$ (*he is speaking of a valve losing 56 per cent of initial pressure*) is equal 28 minutes, the time necessary to get the pressure up again after this valve had blown it down; and the coal which would be consumed in doing this on a 20-feet grate surface would be $\frac{20 \times 20 \times 28}{60} = 186$ pounds. (*The rate of consumption assumed is, it will be observed, twenty pounds of coal per square foot per hour.*) But there is another evil attending on this valve. The [292] water in the boiler would be lowered to a dangerous extent, and it would require to be filled up with cold water, burning a still further quantity of coal, — about 80 pounds, — and requiring a still further amount of time to raise the pressure, equal to 12 minutes, in all 40 minutes."

of nearly $7\frac{3}{4}$ pounds a minute ($\frac{5}{7}\frac{9}{7}\frac{}{5}$=7.74+), instead of at the rate of 2 pounds a minute, when it got to work on smaller reductions (experiments 63 to 71, p. 163), averaging 3.3 pounds, took 46 seconds to restore the pressure, and regained it at the rate of only 4.4 pounds a minute.

The remarkable character of the action is still further shown when we compare the rate of loss of pressure. When losing 59 per cent, the loss was at the average rate of nearly $12\frac{1}{2}$ pounds a minute ($\frac{5}{4}\frac{8}{6}\frac{8}{3}$ =12.5 nearly), while when losing 3.3 per cent from the same initial pressure the loss was at the rate of 4.4 pounds a minute ($\frac{3}{7}\frac{3}{5}$=4.4).*

Adams had said (*in the Crosby record, p.* 297) that one of the "five essential elements appertaining to a safety-valve worthy of the name it bears" was, "*second*, the relieving power of the valve should be twice the generating power of the fires," which is illustrated by a table (*on page* 305, *Crosby record*) of a 20-minute Board-of-Trade trial, in which the valve on the Windsor Castle steamship opened and closed 24 times in 20 minutes, remaining open an average of $2\frac{1}{2}$ seconds and closed an average of 29 seconds, with fires pushed to their utmost; and as the average reduction was .873 pound pressure, never exceeding a pound, this practical test showed an ability to generate pressure about $\frac{2}{1}$ as fast as Mr. Hoadley's apparatus, and the valve showed an ability to take care

* NOTE. — The divisions in above two paragraphs are taken in minutes and decimals, instead of minutes and seconds.

of it about $\frac{1}{5}$ as great as Mr. Hoadley's valve, in the cases of great loss; while in cases of comparatively small loss, the Hoadley valve and steam supply were balanced, and the Windsor Castle practical boiler power stood to the relief power as 1 : 1.35, showing a superiority of relief power over steam generating power of 35 per cent average.

Adams again says (*page* 308, *Crosby record*): "It is a very good boiler, and the fires must be in good condition, that will generate steam at the rate of $3\frac{1}{2}$ pounds per minute in the neighborhood of 70 pounds pressure." Hence the Hoadley generator, which gave 4.4 at 96 or 97 pounds and $12\frac{1}{2}$ at 41 pounds, was an exceptional source of steam.

Having provided an exceptional steam supply, Mr. Hoadley constructed his so-called Webster valve.

In order to get the greatest possible discharge of steam from a safety-valve, it should lift $\frac{1}{4}$ of its diameter, for this will give a steam exit at the ground-joint equal to the area of the steam-way. (Area of steam-way = diameter^2 × .7854, and area at the inner edge of the ground-joint = diameter × 3.14159 × lift = diameter × lift × .7854 × 4; and if lift is $\frac{1}{4}$ of diameter = diameter^2 × .7854.

This would give for an inch valve $\frac{1}{4}''$ lift. But this extreme range is seldom called for, and the ordinary lifts of valves are from $\frac{1}{8}''$ to $\frac{1}{16}''$ (*R.* p. 222), and the range of practical spring compression from a little over .13″ to $\frac{1}{2}''$, as shown by the commercial springs in use, .4″ and .5″ (*R.* p. 35), .4″ (p. 84), .25″ (p.

85), .25″, .31″, .375″ (*R.* p. 209). The spring tension increases with the lift and just in proportion to it, according to Hooke's law (*R.* p. 221), so that the total lifting power required for proper lift beneath the additional surface, will be from 50 per cent of the total initial lifting power, with a $\frac{1}{8}$″ spring and a $\frac{1}{16}$″ lift, to 25 per cent of the initial lifting power, with a $\frac{1}{2}$″ spring and an $\frac{1}{8}$″ lift.

Now the initial area of the Webster valve made by Mr. Hoadley was 1.03 square inches, and the total initial and supplemental areas was 4.15 square inches. So that the supplemental area was a little more than three times the initial area. To have put a $\frac{1}{4}$″ spring upon it with a $\frac{1}{16}$″ lift would have required, at 100 pounds initial pressure, the pressure in the huddling chamber to be reduced to $\frac{2}{3}^{5}$ pounds, or about 8 pounds, at most, and this with an exceedingly large expansion room and a stricture of .22 square inches.

How, then, to get a lift which would relieve the boiler and not waste too much pressure was the problem, — a lift in the vicinity of $\frac{1}{16}$″ (.06″), with a ratio of initial area to an additional area of 1:3.

It could not be done.

Mr. Hoadley adopted a spring of .11″ compression for 100 pounds (p. 147); he fixed the flange at .005″ (p. 121) *above* the case *within* which it was to be adjusted (*R.* pp. 47, 151, 152, cross-ints. 79–81).

As the area of the initial surface was 1.03 square inches, the spring sustained 103 pounds by a compression of .11″ (*R.* p. 120). As the area of the ad-

ditional surface was 3.12″ (4.15″—1.03″=3.12″, p. 120), and the pressure in the huddling chamber was 5 pounds (p. 123), the additional lifting force was 15.6 pounds, and the lift was, by the Hooke law of spring, $\frac{156}{1030}$ (15.15 per cent) of .11″=.0167″ (about $\frac{1}{60}$″), instead of .0625″ ($\frac{1}{16}$″). In other words, the lift was hardly 27 per cent of the least allowable lift; and instead of giving a relief opening at the valve-seat of .226″ area (3.61″×.0625=.226″), it gave a relief opening of only .06″ area (3.61″×.0167″=.0603″), —27 per cent of the commercial standard of efficiency.

He thus, as Mr. Forbes said, "so limited the lift of the valve as to render it ineffectual in discharging a proper quantity of steam proportioned to its size" (p. 220).

These are irrefragible proofs that the "Defendant's Webster Valve," so called, was not what Webster invented, not a safety-valve at all, but a mere piece of "monkey work," and what Mr. Forbes called it (p. 220), "a cheat and a swindle." The materials of this proof are contained in the bewildering columns and tables of Mr. Hoadley himself, and it is hardly possible that he didn't know there was in these tables "a darkening of instruction by words without wisdom."

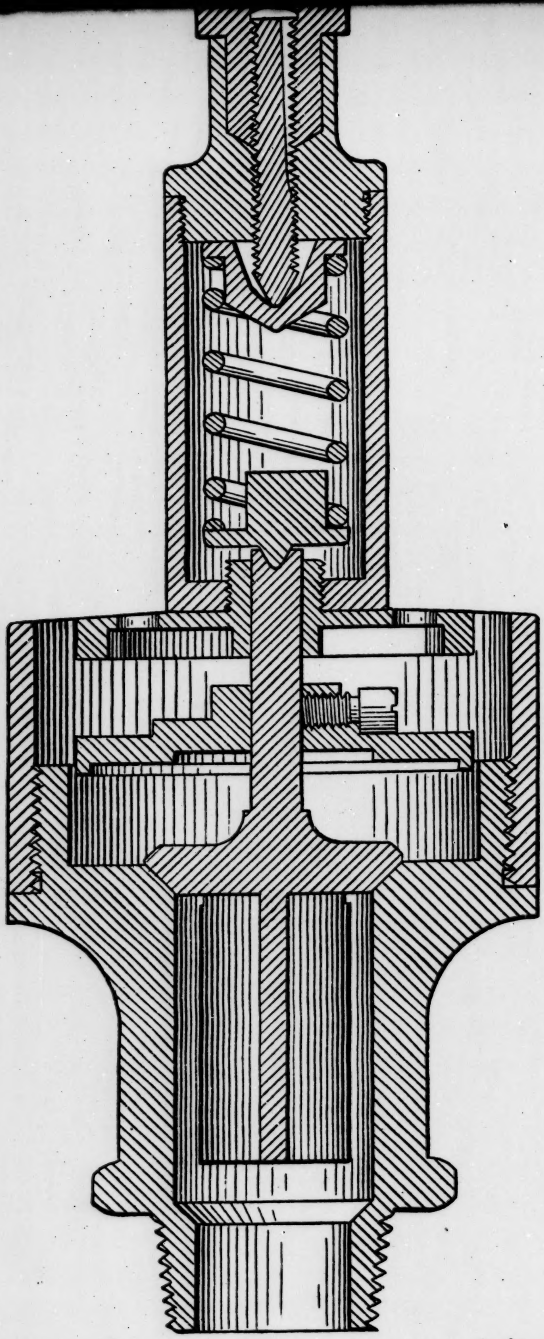
Mr. Hoadley got all this education for this puzzle-work in 1879–80 (*R.* p. 149, cross-ints. 65–67), and it was in May, 1880, that he made the calculation which gave him this strength of spring to use, not having

any idea that any spring in common use could be successfully employed (*R.* p. 148, cross-ints. 59–62).

This exposure of fallacies would rest here as a case of enthusiastic self-deception in an expert, were it not for an attempt made to delude about the lift, and convey the idea it was about $\frac{1}{16}''$.

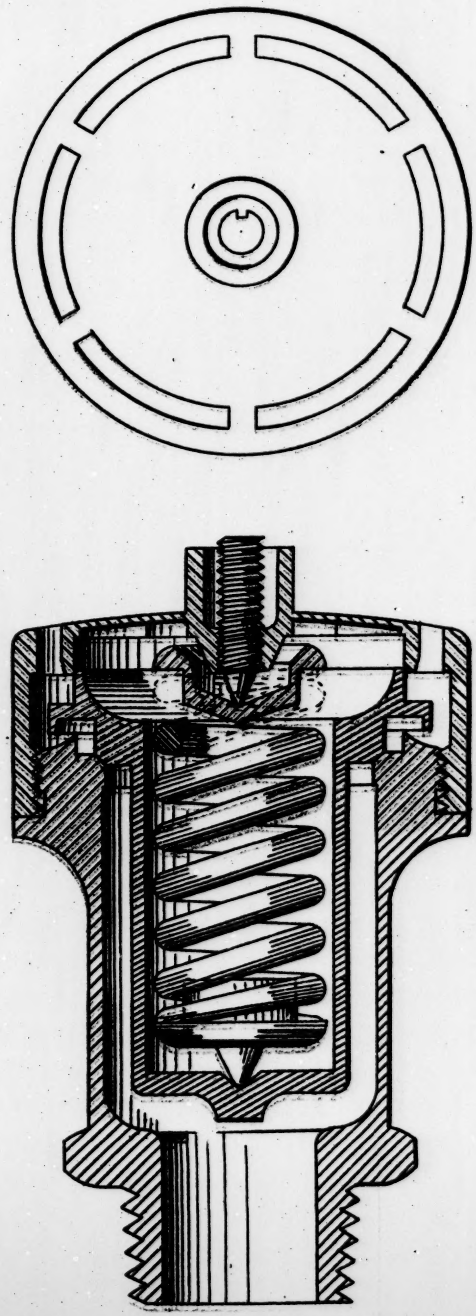
On the last line of page 120 of record is this statement and saving clause about lift: "Lift of valve *required to make cylindrical opening at inside of ground-joint equal in area to area of stricture*, .06 inches."

There now remains to contrast the Hoadley embodiment of Webster's instructions with the real embodiment. The picture from which the valve is supposed to be made is at page 47, fig. 3. The valve is described by Webster as loaded by a lever (*R.* p. 46). The valve, "Complainant's Exhibit Webster," is conceded (*R.* p. 167) to be a fair embodiment of Webster's device when loaded by a lever and spring. A cut of this complainant's exhibit is here shown in contrast with the cut of the Hoadley embodiment.



Defendants Exhibit Webster
Valve fig 3 p 120 * 220.

Complainants Exhibit Drawing Kunkle A.
(Without Adjustable Screw Ring.)



Defendants Exhibit
Value fig 3 p 120 * 220.

The patent drawing shows the flange immersed in the cylinder .08″ (*R.* p. 150). The defendant's exhibit is shown with the immersion at .045.

The following table from Hoadley's own experiments shows it not to be a merchantable valve, partly because it does not open at uniform pressures with the same spring, partly because it loses excessively, 3 or 4 per cent being the extreme limit of loss usually desired (*Hoadley*, *R.* p. 133, experiment 13).* The uniformity of opening pressure with the same adjustment of spring, and the worst percentage of loss in commercial valves will be seen from the experiments in this case to be far better than the best of this.

* The only exception to the rule that 4 per cent or 4 pounds is the maximum desirable loss, or even the maximum loss ever desired by anybody, whatever his engineering notions, is in the case of Mr. Hoadley himself, who left the business of engine-making, or the business left him, in 1878 (*R.* p. 182, cross-int. 172), and who, against general advice, used 12 safety-valves only, adjusted to lose 12 pounds on a maximum pressure of 132, with a working pressure of 120 (*R.* p. 183, cross-ints. 173–176). This rash act was less than six months before he gave up the engine business for the "pleasant and profitable" field of "scientific and mechanical expert in patent causes and other causes involving mechanical and scientific questions" (*R.* p. 111, int. 1; p. 113, last paragraph, int. 2; p. 183, cross-int. 173; p. 182, cross-int. 172).

This exceptional use, of 12 safety-valves only, is his single ground for saying that the best reduction by the Webster valve as Webster described it, which gives a loss of from 5.9 per cent to 12.6 per cent (*R.* p. 171, paragraph 4), was within the limits *desired in practice*.

He was the only man who ever desired it in practice. He only desired a dozen. And then he desired, or was desired, to practise this mechanical Tom-foolery no more.

He calls this occasional act "proof" of what "*is* desired in practice." The Court may recall Mr. Sam Weller's remark at Bath, "me and the other fashionables only come down last night," as well, perhaps, as the more classical fable of the fly and the carriage wheel.

But an irregularity even worse, is, that the same adjustment of valve does not give like results in successive actions.

See *R.* pp. 167–170.

Regulation by Immersion of Compensation Flange. Depth of Immersion in decimals of an inch.	Opening Pressure in pounds to square inch.	Closing Pressure in pounds to square inch.	Loss in pounds.	Loss in per cent of opening pressure.
.111	104	45	59	57
.055	102	49	53	52
.028	95½	73½	22	23
.014	100	87½	12.5	12.5
	97½	85	12.5	12.6
.01	100	91½	8.5	8.5
	100	91½	8.5	8.5
	98	92	6	6.1
	98	92	6	6 1
	99	92	7	7 1
.007	102	94	8	7.8
	102	97	5	4 9
	100	95	5	5

A seeming conformity in results to adjustments may be made by averaging the percentages of reduction against .014 (taking no notice of the difference of opening pressures, 100 and 97½ pounds, nor working pressures, 85 and 87½ pounds), against .01 when they vary from 6.1 to 8.5, and where the opening pressure varies 2 pounds, and the loss of pressure varies 2½ pounds, against .007, at which point commercial limits are approached, and the reductions

vary from 4.9 per cent to 7.8 per cent, from 5 pounds to 8.

With regard to anticipation, then, the case is left where this Court left the Crosby case on January 19, 1885. And the evidence here adduced can only modify the words above italicised from the opinion in 113 U.S. p. 174, to read in substance as follows: —

"*But the evidence shows that valves made with the proportions shown in the drawings of the Webster patent* [if fitted with springs which permit them to have, or so arranged that they do have, a lift sufficient to make them commercially efficient], *work with so large a loss of boiler pressure before closing, as to be practically and economically worthless.* [If not so fitted and arranged as to give a sufficient lift, they may simulate the action of Richardson's valve under certain exceptional experimental conditions, but lack entirely its distinguishing quality — relieving power on an ordinary boiler.]"

The proof of this first bracketed phrase is found on page 166, record, where "Defendant's Exhibit Webster No. 3" had a lift of .2", showing a pressure of 57 pounds in the huddling chamber;* the loss of pressure was 58.8 pounds to the square inch out of 100 pounds initial. And this is confirmed by a statement on page 165

*Total lifting power under initial surface is 100 x initial area, in inches, and is held by .11-inch compression of spring. Total lifting power under supplemental surface is $\frac{.20}{.11}$ x 100 x initial area. And pressure to square inch is as areas; or, in arithmetic, initial pressure to inch : supplemental pressure to inch :: 100 : $100 \times \frac{20}{11} \times \frac{1}{3 \cdot 12} = 57$.

about the lift in the same experiment, when it is stated after the valve had blown down 40 pounds to have been still .17, showing a pressure in the huddling chamber then of 31 pounds to the square inch.*

INFRINGEMENT.

Complainants pursued three forms of valves: Kunkle A (*diagram, R.* p. 34), which was only alleged to infringe the patent of 1866; Kunkle B (*diagram, R.* p. 36), which was alleged to infringe both patents, and Kunkle C^2 (*diagram, R.* p. 86), which was alleged to infringe both patents. Full-size sectional diagrams of these illustrate this brief.

The first thing noticeable in these valves is that they are put up in a short cylindrical case, and that the steam, escaping from beneath the extended surface of the valve-head, is discharged, not into the open air direct, as in Richardson's valve, but into an annular steam-channel which opens through small slits in the top of the case to the open air.

The annular channel is full of steam when the valve is blowing, which resists the escape of steam from beneath the valve-head just as the metallic walls of Richardson's stricture do; and when the defendant's so-called "Hartley," "Webster" and "Waterman" valves were got ready to send through their motions, for the purpose of showing how little Richardson had done when he instituted a mechanical policy of boiler insurance perpetual, and without annual pre-

* The same formula, *multatis mutandis*, gives $\frac{1}{3.12} \times \frac{17}{11} \times 60 = 30$.

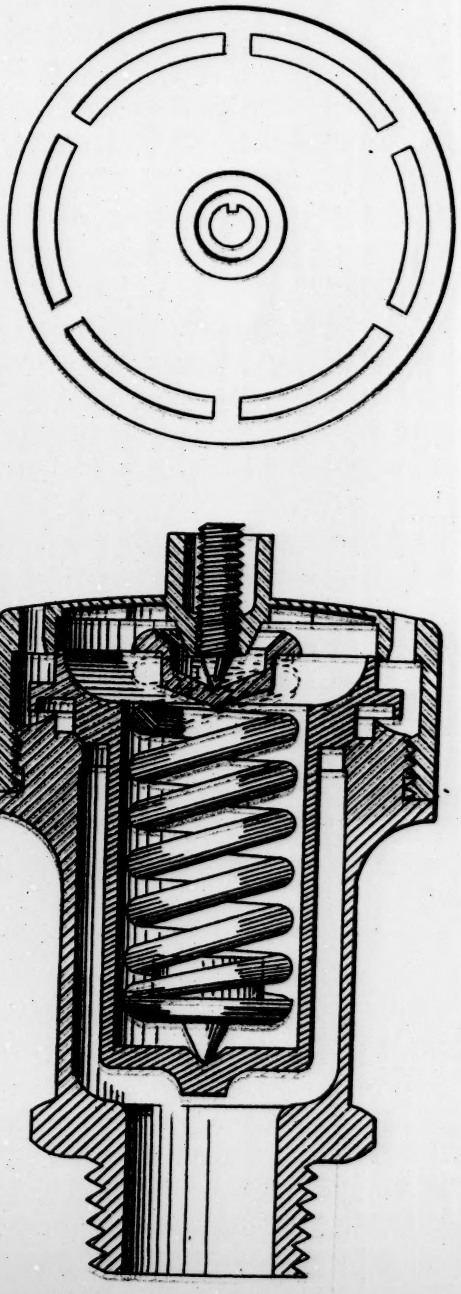
miums, the Kunkle cases into which they were put were honeycombed with holes to get rid of this back pressure (*R.* pp. 157, 158, 159; *Hoadley*, cross-ints. 105–110).

The steam in these Kunkle valves from beneath the additional surface is discharged not into atmospheric pressure, but into a back pressure greater than atmospheric pressure, and so the back pressure caused by the metallic walls of the stricture described by Richardson is produced by the long-known device of crooked passages and steam resistance (*R.* p. 188, cross-ints. 199–202; p. 189, cross-int. 205; p. 190, cross-ints. 209–211).

What Richardson prescribed was to retain enough, and just enough, of the initial pressure of the boiler to lift the valve against the spring; enough, and just enough, to relieve the boiler from undue strain, only; discharging all the danger, retaining all the usefulness, keeping fire and steam as slaves and servants, without giving them a chance at the mastery. The steam itself was to be so guided and controlled as to do this work. The very force which strove for the mastery must waste itself in the strife, and by reason of the strife; and the slave of the lamp always be kept the slave of the lamp, and never allowed to become a free and untramelled Afrite.

These Kunkle valves A, B and C^2, each and all have the initial area, the additional area, the huddling chamber beneath the additional area, and an orifice leading from the huddling chamber into the cavity of

Complainants Exhibit Drawing Kunkle A
(Without Adjustable Screw Ring.)



miums, the Kunkle cases into which they were put were honeycombed with holes to get rid of this back pressure (*R.* pp. 157, 158, 159; *Hoadley*, cross-ints. 105–110).

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What Richardson prescribed was to retain enough, and just enough, of the initial pressure of the boiler to lift the valve against the spring; enough, and just enough, to relieve the boiler from undue strain, only; discharging all the danger, retaining all the usefulness, keeping fire and steam as slaves and servants, without giving them a chance at the mastery. The steam itself was to be so guided and controlled as to do this work. The very force which strove for the mastery must waste itself in the strife, and by reason of the strife; and the slave of the lamp always be kept the slave of the lamp, and never allowed to become a free and untramelled Afrite.

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These Kunkle valves A, B and C', each and all have the initial area, the additional area, the huddling chamber beneath the additional area, and an orifice leading from the huddling chamber into the cavity of

the case which opens to the open air, which orifice is proportioned in size to the strength of the spring, so that the valve operates as a "pop" safety-valve with a small reduction of pressure.

This court held in the Crosby case (113 U.S. 176) and nothing has been advanced in this case to militate against or modify the construction of the Richardson patent as there given — that the claim of the patent of 1866 covers "a valve in which are combined an initial area, an additional area, a huddling chamber beneath the additional area, and a strictured orifice leading from the huddling chamber to the open air, the orifice being proportioned to the strength of spring, as directed."

The valve Kunkle A is, according to Mr. Forbes, made and proportioned as set forth in Richardson's patent of 1866, and operates identically like it (*R.* p. 35). If the wall rising from the seat outside the ground-joint is cut away, the stricture is destroyed (*R.* pp. 213, 214); but if the wall remains, the stricture remains, as shown by Mr. Hoadley's experiments with Kunkle A^2, A^3 (*R.* pp. 132, 133).

An attempt was made to show that the extra lift of this valve "Exhibit A" was due to the force of impact, or, in other words, to the weight of steam and its velocity (p. 189, cross-int. 206), and not to the retention of the boiler pressure in part by a mechanical obstruction to its escape (*R.* p. 131). But the experiment in which this is stated, denies it. For where impact is greatest, pressure is least (*R.* p. 131,

experiment 11, Nos. 1, 2; p. 189, cross-int. 207). Mr. Hoadley can give no explanation of the fact that where impact aids residual pressure to lift the valve, and the sum of the two is weighed, the force exerted is two pounds to the square inch less than where there is no force of impact; but he is certain of the fact (*R.* p. 189, cross-ints. 207, 208). The fact is this: under the initial surface we have 100 pounds to the inch; just outside the ground-joint, 20 pounds; just under the additional surface, 18 pounds; just inside the case near the exit orifices, 2 pounds (*R.* p. 131, experiment 11). Now this explanation cannot be doubted, that the steam is "huddled" in the case between the edge of the flange and the escape slots, by the obstacle of the narrow slots (Drawing, *R.* p. 34, and "Drawing Kunkle A," *supra*, p. 37), and again huddled beneath the additional area by the impediment placed there.

The disguise, therefore, in this Kunkle valve A consists in a superposition of huddling chambers, or in a subdivision of one huddling chamber into two parts, by an intermediate obstacle to the flow of steam.

Of course the only huddling chamber, immediately operative to lift the valve, is the one which is beneath the additional area; for only that one has a movable cover.

The external huddling chamber operates merely to increase the pressure in the internal one, by adding at the door of communication a resistance which acts

just as a metallic wall would act, and as it has been known for years before 1866 it would act (*R.* p. 190, cross-ints. 209–211; p. 189, cross-ints. 203, 204).

Whatever difference, therefore, there is between Kunkle A and the Richardson valve of the patent of 1866 is due to a modification of no greater importance than would be that of dividing a brigade of forty-eight hundred men, according to the Prussian system, into two regiments of three battalions of four companies each, each company having about 200 men ($2\times3\times4\times200=4800$); or, according to the French system, into three regiments of two war battalions of six companies each, each company having about 150 men ($3\times2\times6\times134=4824$); or, according to the old English and American system, into five regiments of one battalion each, each battalion having ten companies and each company about 96 men ($5\times10\times96=4800$).

It is a mere question of detail, as all the Kunkle valves (A, B and C') complained of are alike in this respect, they all infringe the patent of 1866; for the additional lifting force is applied to the additional area by the pressure of steam in the huddling chamber beneath the additional area, being retained therein by a strictured orifice leading therefrom.

And the only reason given why there is no infringement is the erroneous notion that Richardson announced a necessary relation to exist between the size of the stricture and the opening at the ground-joint, which we have seen was not so.

Defendants' construction of the Richardson patent of 1866 fails to relieve them, and the infringement is plain in all those of the valves pursued.

THE RICHARDSON PATENT OF 1869.

The stricture of the patent of 1866, when once made, was invariable, without the application of tools, and the reduction of pressure obtained could be regulated in two ways only, each of which involved, practically, the removal of the valve from the boiler. One was to change the spring and substitute one of greater or less tension at the pressure required. The other was to remove the valve, and, by aid of a cutting or burnishing tool properly applied to the metal in the vicinity of the stricture, make it wider or narrower as desired.

Of course, in the first adjustment of the valve, this was a tedious and expensive operation, and when in use, impractical.

In 1867 Richardson thought of applying a screw-ring to the stricture to regulate its size and action, and placed one upon the edge of the valve proper (*R.* p. 80), afterwards taking the patent of January 19, 1869, in suit, which describes a somewhat different detail, huddling only part of the steam.

It was held in the Crosby case (113 U.S. 177):

"Richardson is also entitled to cover, by the claim of his patent of 1869, under the language, 'the combination of the surface beyond the seat of the safety-valve, with the means herein described for regulating or adjusting the area of the

passage for the escape of steam, substantially as and for the purpose described,' the combination with the surface of the huddling chamber, and the strictured orifice, *of a screw-ring*, to be moved up or down, to obstruct such orifice more or less, in the manner described."

Two forms of valves made by Kunkle have the screw-ring which may be moved up or down to obstruct an orifice more or less, and thereby modify the action of the valve, Kunkle B and Kunkle C[2].

Tests of these valves with springs of different strengths show that to obtain similar action of the valves with springs of different degrees of compression, the screw-ring of the Kunkle valves must be moved up to obstruct the orifice more when a comparatively strong spring is used, and down, to obstruct it less when a comparatively weak spring is used, thereby showing that this orifice is proportioned to the strength of the spring (*R.* pp. 37–41), and thus confirm our conclusions as to the embodiment of the invention of the patent of 1866 in these valves, — and also that with the same spring the movement of this screw-ring modifies the action of the valve with regard to the loss of initial pressure, as Richardson says (*patent of* 1869, *R.* p. 66, 4th ¶), "so that the valve may be set to close at any desired pressure below the pressure which will open."

With a $\frac{5}{32}''$ spring (.156″) the same reduction may be got as with a .4″ spring, but the opening from the huddling chamber to the case will differ.

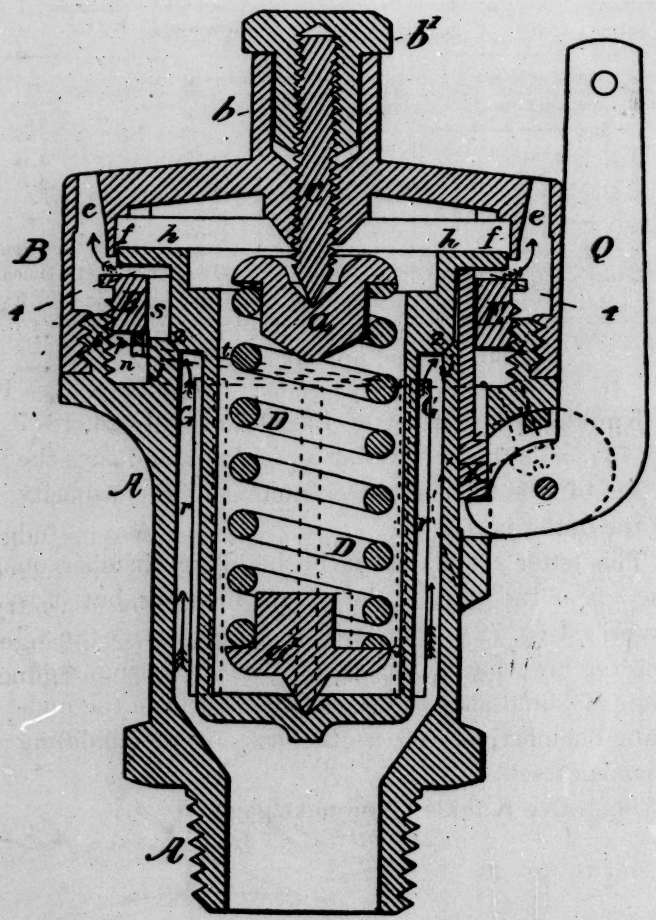
5-32 INCH SPRING.		REDUCTION.		.4 INCH SPRING REDUCTION.			
Ring is open notches.	Height of opening between ring and flange.	Pounds.	Per cent of initial pressure.	Ring is open notches.	Height of opening between ring and flange.	Pounds.	Per cent.
4	4-594	7	7	11	11-594	7	7
5	5-594	6.5	6.5	13	13-594	6	6
6	6-594	6	6	15	15-594	5.5	5.5
7	7-594	5.5	5.5	17	17-594	5	5
8	8-594	5	5	19	19-594	4	4
9	9-594	4.5	4.5	20	20-594	4.5	4.5
10	10-594	4	4	21	21-594	3	3
11	11-594	3	3				

(p. 36, 2d par. pp. 37–75, 38, 40).

Kunkle in his patent of 193,411, of July 24, 1877 (p. 73), calls this screw-ring a *regulator*, and says the object of it is to increase or diminish "the capacity of the outlet port *s*."

This letter *s* is placed in the huddling chamber on the left of the valve in the patent drawing, but it is described (p. 72) as indicating a "serpentine port," and the lowering or raising of the screw-ring *regulator* E would alter the size of the exit from the huddling chamber, as well as the size of the huddling chamber itself.

The valve Kunkle C^2 on next page



was also submitted to tests and operated substantially as did Kunkle B (*R.* pp. 83–85), requiring an area of stricture as follows: —

Spring compression.	Spring compression.	Area of stricture.	Reduction.	
			Pounds.	Per cent.
.25″ for 80 lbs. Experiment 7	.4″ for 80 lbs. Experiment 3	.8″ 1.12″	6 6	7.5 7.5
Experiment 9	Experiment 5	1.12″ 1.66	3.5 3.5*	4.4 4.4

* The table on page 85, Record, corrects an error in 9th line from bottom, of "three pounds" to "three and a half pounds." Experiment 5, 12 notches open, loss of pressure three and a half pounds, has by Ex. 25 on page 84, a value of stricture area of 1.66″.

It results from all this that the Kunkle valves B and C² infringe the Richardson patent of 1869.

SUMMARY.

The Court below committed four errors in its judgment in this cause, as above assigned, and the decree should be reversed and the cause remanded for entry of a decree sustaining the patents, finding infringement, awarding an account on both, and an injunction on the patent of 1869.

No. 29 Pemberton Square, Boston, Mass.,
September 3, 1885.

Office Supreme Court U. S.
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CLERK.

119-40

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1885.

CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

APPELLANT'S BRIEF

ON THE AMENDED ANSWER AND STIPULATED FACTS ABOUT WATERMAN.

THOS: WM: CLARKE,
of Counsel.

Supreme Court of the United States.

OCTOBER TERM, 1885.

No. 255.

CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

APPELLANT'S BRIEF

ON THE EFFECT OF THE TRANSACTIONS BETWEEN RICHARDSON AND WATERMAN.

SITUATION AND CONTENTION.

By stipulation the defendant has been allowed to amend his answer in this Court so as to make available the defence of *estoppel in pais* on Richardson and his assigns, to contest the invention by Waterman, of all that this Court declared in the case *Consolidated Safety Valve Co.* v. *Crosby Steam Gage & Valve Co.*, 113 U.S. 157, to be included in the Richardson invention patented in 1866, September 25 (*Stipulation*, p. 22).

EVIDENCE.

The evidence to support this contention is in the deposition of Henry Waterman, now dead, the Waterman patent of 1853 and reissue thereof, and an agreed

statement of a few additional facts. The following statement, directly from the record, in chronological order, is conclusive against the notion of estoppel, or that the public derived any rights from the acts of Richardson and his associates with regard to the Waterman patent and reissue; and shows that they made unnecessary sacrifices, out of business prudence and for the sake of peace, and that their act was simply the extinguishment of a bad adverse claim of title, by purchase, instead of by litigation.

ORDERLY STATEMENT OF THE WATERMAN AFFAIR.

Henry Waterman, in or before the year 1853, invented a method of loading safety-valves intended to give steadiness of downward pressure to the weight on the safety-valve of a moving locomotive, by combining a "dash-pot" with the ordinary dead weight, and took a patent for it (*Stipulation*, p. 3, int. 3; p. 6, cross-ints. 10, 15; pp. 9–14, *Waterman patent of* 1853; p. 21, *drawing*).

At the time he made this invention he also made from his own design, a form of valve, which had an extended surface, and a huddling chamber beneath the extended surface; and this peculiar valve, fitted with the weight and dash-pot, was put on the engine "Lowell" of the Hudson River Railroad (*Stipulation*, p. 3, int. 3; p. 15, int. 27; pp. 7, 8, 21, *patent drawing*).

This valve on the "Lowell" opened with great promptness, blew with great violence, would reduce

the boiler pressure more than fifteen pounds, and would discharge quantities of water as well as steam (*Stipulation*, p. 3, int. 3; p. 7, *Explanation*, 1).

The form of valve put on the "Lowell" was illustrated in the drawing of the Waterman patent of 1853 (*Stipulation*, pp. 7, 8, 21), and was described in the patent as an "ordinary safety-valve" (*Stipulation*, p. 9; *Waterman patent of* 1853).

No valve other than the one on the "Lowell" was made under Waterman's auspices till 1867, after the date of the Richardson patent, and the introduction into use of the Richardson valves (*Stipulation*, pp. 15, 16, ints. 27, 29); when Waterman procured a copy of the Richardson patent and a specimen of the Richardson valve, and caused a valve to be made, somewhat modified from the valve of his patent drawing and from the valve he had made for the "Lowell."

Neither the valve of the patent drawing nor that on the "Lowell" had any stricture, but the "Lowell" *valve was as tight as could be made to work without friction* (*Stipulation*, pp. 7, 8, 21; *patent drawing*, pp. 15, 16, int. 27). It had a less proportion of supplemental to initial area, and in that respect imitated Richardson. And the size of the stricture was enlarged from time to time in his experiments, till a proper amount of reduction was reached.

WATERMAN TAKES IN RICHARDSON & CO., AND IS ADMITTED A PARTNER.

Richardson, in December, 1866, assigned his patent of 1866 to the firm of George W. Richardson & Co., consisting of himself, George Gould and William H. Poor (*R.* p. 226), and Richardson was to receive half of the net profits of the business.

Waterman, after his experiments at Greenbush in 1867, applied for admission to the firm, and Gould and Poor wanted to admit him; Richardson did not (*Stipulation*, p. 21).

Richardson then went to see Waterman, and was shown the Waterman patent of 1853 and told Richardson (*Stipulation*, pp. 14, 15, cross-int. 22), "I can make that valve do just what yours does. It is folly for us to quarrel. I can't make my valve, because I never used a spring upon it, and only can use it in connection with a weight; and if I reissue my patent you can't make your valve till the expiration of my patent, so there will be a dead lock here for a little over seven years."

Having put the situation in this light, by what was substantially a threat of blocking Richardson's business for a considerable time, and at any rate compelling considerable expenditure to defend the business; he proposed softened and chastened blackmailing terms. He would come into the partnership to a third interest only, but would contribute half the capital, and the Waterman patent.

This arrangement was made. Waterman got a third interest, by making half of the monetary investment requisite for the business.

NO ONE BUT WATERMAN RESPONSIBLE FOR THE REISSUE.

He then prepared the reissue specification, and Richardson witnessed his signature. It is not pretended to be proved that Richardson knew the tenor of the paper he witnessed, and the evidence of Waterman rather refutes than affirms this proposition (*Stipulation*, p. 17, int. 33).

RICHARDSON & CO. BOUGHT THE WATERMAN REISSUE NOT TO USE AGAINST THE PUBLIC BUT TO PROTECT THEMSELVES.

Neither Richardson nor any other member of the firm of George W. Richardson & Co., save Waterman, had any part in the acts which resulted in the reissue and extension of the Waterman patent (*Stipulation*, pp. 21, 22).

No reference to the Waterman patent was ever made on the valves made by George W. Richardson & Co. No suit was ever brought on the reissue or extension of the Waterman patent. No threat of suit was ever made. Even in making licenses, the Waterman patent was only mentioned once, so far as known (*Stipulation*, p. 21, *R.* 227), where a territorial right was sold to Collis P. Huntington.

LEGAL PROPOSITION FOR DEFENDANTS TO MAINTAIN IF THE WATERMAN DEFENCE IS TO PREVAIL.

When, therefore, we fit together the facts in the terms of a headnote proposition, the defendants' legal contention is, —

If a patentee, in order to be allowed to profit by a subsequent inventor's skill —

Falsely claims to have anticipated the subsequent inventor;

Threatens him with blackmailing and causeless litigation;

And succeeds in his scheme of buying into the subsequent invention, at the rate of a third interest for half the expenses;

And then obtains a reissue of the prior patent, which covers the subsequent invention, but which is void on its face, without the knowledge of his partner of what he is doing, or that it is void, and assigns his void and illegal grant to the partnership, who neither make, nor threaten to make, use of it against the public or any part of the public:

The assignee is responsible for the illegal act of the assignor in reissuing the patent, and either forfeits the protection of his vested grant and valid patent, or is deemed conclusively to have disclaimed them!

"Crowner's quest law" in Hamlet doesn't equal this.

CONCLUSION.

The Waterman transaction presents no defence.

Boston, October 3, 1885.

119-45

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CLERK.

SUPREME COURT OF THE UNITED STATES.

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CONSOLIDATED SAFETY VALVE COMPANY

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APPELLANT'S BRIEF

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APPELLANT'S BRIEF

ON THE ORDER TO BE MADE IN BEHALF OF APPELLANT.

PATENTS HAVE EXPIRED.

In this cause both the patents in suit have expired.

Cases of this sort have hitherto been comparatively rare, and the contents of the decree to be entered, to give full relief, are therefore a matter of interest, to which it is proper to invite the attention of this Court.

OBJECT OF DECREE IN EQUITY.

The final decree in a suit in equity ought to put the parties as nearly as possible in the situation they would have held had one of them not invaded the rights of the other. And the accounting for profits rests upon the equitable doctrine that a wrong-doer must make restitution of the advantages of his wrong-doing to the person wronged.

ACCOUNTING ORDER AFTER PATENT HAS EXPIRED.

In this readjustment, an accounting for profits and damages may be ordered, since the Act of 1870, notwithstanding the fact that no injunction can be issued.

Lake Shore & Mi. S. Ry. Co. v. *Car Brake Shoe Co.*, 110 U.S. 229.

Cons. S. V. Co. v. *Crosby Steam Gage & Valve Co.*, 113 U.S. 157.

COMPLETED GOODS, MADE BEFORE, MAY BE ENJOINED AFTER PATENT HAS EXPIRED.

On English authority, followed at circuit in this country, an injunction can be ordered against goods made during the life of the patent and to operate after the term.

Crossley v. *Derby Gas Light Co.*, 4 L.J., (N.S.) ch. 25, Webs. P.C. 119.

Price Patent Candle Co. v. *Baumen P. C. Co.*, 4 K. & J. 727.

Toledo Mower & Reaper Co. v. *Johnston Har. Co.*, 24 Fed. Rep. 739.

Gottfried v. *Moerlein*, 14 Fed. Rep. 170.

Curtis on Patent, § 436.

American Diamond Rock Boring Co. v. *Sheldon*, 1 Fed. Rep. 870.

American Diamond Rock Boring Co. v. *Rutland Marble Co.*, 2 Fed. Rep. 356.

FOR FULL RELIEF AN INJUNCTION SHOULD, AT TIMES, GO FURTHER AND REACH GOODS IN PROCESS.

Among things existing during the life of the patent, besides the completed goods which manifestly infringe, there are, — when the patent is for a special machine, and particularly if a small and simple machine, which, by its shape and relations of formed parts with other parts, and particularly if those other parts are vacillating parts, which by elasticity yield, and by resiliency restore positions and call into action expansive forces hitherto not usefully harnessed,— what may be called *accessories* or *the paraphernalia of infringement;* things which have been called into existence solely, and which have as their sole cause, purpose and reason of being, the support, sustenance and prosecution of the infringement itself. But really these things are goods in process, necessary things to make, in order to have complete goods at all.

Limiting the nature of goods in process by exclusion, they are not the machines for using the patented thing and which are useful with other tools, for these, on authority, are clearly out of the scope of an injunction.

Diamond Rock Boring Co. v. *Sutherland Falls Marble Co.*, 2 Fed. Rep. 353.

But they include the special things by which alone defendant has been able to make the patented thing,

the indispensable outfit for the unlawful business and for that only. Such are the patterns for moulding the infringing goods, the working drawings for the infringing goods, the castings unfinished or in process, useful for no other goods, the wood cuts, plates, circulars and catalogues made to advertise them and promote their sale, and only their sale, the milling and other special tools to cut and shave the castings into final shape, but not including the lathes, tool holders, or chucks which hold the castings and tools at work; such also are the templets and gauges used to lay out and measure the salable work in progress. All these are clearly things which owe their existence to the unlawful business, and are useful only to carry on such a business after the term of the patent, and are inherent parts of every complete thing.

These, if accessories, should follow the fate of their principal.

In fact they are the principal, for in trespass trespassers are not graded, and as they inhere in the complete thing they are part of that thing, a part on hand.

An injunction in the life of the patent disables them, natural decay or purposeful destruction puts them out of the way in a case where the patent has any term after a decision.

IF THEY EXIST WHEN PATENT EXPIRES THEY SHOULD BE DISABLED.

But when the patent expires *pendente lite*, if these are not disabled by the Court by its injunction, the wrong-doer enters upon the term of freedom, with advantages over the lawful trader. Hence these advantages of an infringer should be taken from him.

Another reason for the elimination of these paraphernalia of infringement is, that in the accounting, in estimating the cost of the infringing goods to ascertain infringer's profits, the cost of these drawings, patterns, templets, gauges, special tools, cuts, plates, circulars, catalogues, work unfinished and in progress, are legitimate items in the cost of production, and as the cost of making them is to be used to reduce complainant's profit in the accounting, defendants should be deprived of them as tools or parts on hand.

HOW TO DISABLE AND LEAVE THE MATERIAL PROPERTY TO DEFENDANT.

It is not asked that they be confiscated and delivered to complainant, but that their usefulness as tools to the defendant be taken away, and he be deprived of a means of prosecuting a business, which, in its unlawful origin and career, evolved and originated and paid for these means. Let the patterns be reduced to kindling wood; defendant may have the wood. Let the engravings of the wood-cuts be planed off, the

drawings sand-papered, the tools made into scrap, the blanks in metal be remelted ; the defendant may retain the material when its infringing character is gone, and he may charge up the cost of making his tools and castings at proper rates, and allow for them when scrapped, under inspection, as old metal.

AUTHORITY FOR DESTRUCTION OF INFRINGING GOODS.

The English rule, without any more statutory authority than our own, prescribes that the infringing goods shall be destroyed or delivered up.

Betts v. *De Vitre*, 34 L.J., (ch.) 289, 1 Seton's Dec. 354 (ed. 1877).

Plimpton v. *Malcolmson.*, 1 Set. Dec. 354, (ed. 1877.)

Tangye v. *Wood*, *ibid.* 353.

Badische Anilin, &c., v. *Levestein*, L. R. 24, Ch. D. 176.

Of these decrees, *Betts* v. *De Vitre*, L.R. 6, H.L. 319, and *Badische* v. *Levestein*, L.R. 29, Ch. D., 366, were bonded and appealed, and the *Betts* case decided after the expiration of the patent. The *Badische* case was reversed on appeal. The *Tangye* case I have not traced, and in the *Plimpton* (roller-skate) case, I was told by the plaintiff, the property was actually delivered and destroyed.

MANDATE SHOULD PERMIT A PROPER INJUNCTION.

Complainant, therefore, should not be precluded by the mandate from obtaining an injunction against use or sale of infringing articles made during the life of the patents, and against use or sale, or disposition, except to complainant, of the working drawings of infringing valves, and patterns of infringing valves, made during the life of the patents, or made from working drawings made during the life of the patents, or of castings finished or in progress and made from such patterns, or of *special* tools (to be used in machines) made or designed during the life of the patents expressly for these infringements, or of wood-cuts, plates and letter-press made during the life of the patent, or taken off or reproduced from such cuts or plates so made and designed and devised solely to prosecute the work of infringement, and from the use of all printed matter in the way of circulars and catalogues made from such cuts and plates ; and the same should either be destroyed under inspection, or delivered to complainant.

BILL SUFFICIENT FOR THE ORDER.

The bill contains the prayer for general relief, under which it has been often held that an appropriate injunction may be ordered.

ANALOGIES FEW.

The situations analagous to this, where injunction was granted or continued after the life of the patent, are few.

The cases in which injunctions during the life of the patent have been granted are many.

LACK OF PRECEDENT EXPLAINED.

Yet this motion is without precedent, except that it has been made in Massachusetts in the Crosby case on the second of these patents and refused as premature, with privilege to renew at the close of the accounting, and in a Crosby case on the first of these patents, where it was held the mandate did not allow an injunction.

It is, therefore, proper to explain why it has never been made before; for, if the arts did not require it to be made before, the lack of precedent does not militate against it, any more than the precedents which allow a captain to pledge his ship in bottomry, justify such a pledge when the captain is at one end of an ocean telegraph and his owners and underwriters are at the other end.

"*The Julia Blake*, 16 Blatch. 490, and cases cited.

The Latin maxim "*Cessante ratione cessat ipsa lex*" has an equally true converse. The remedies of the law adapt themselves to the conditions of society.

Now it is true that the use of patterns for castings

is old, but the use of patterned shaping tools in wood-working machinery came in with the variety-moulding machine about thirty-five years ago, and of mills in metal working much later, and has only been common within ten years. The elaborate use of illustrated circulars, of special advertising, is a thing borrowed by the machinist from the proprietary medicine man, and is the result of process engraving and of the commercial traveller system of distribution, which, in these specialties, is an affair of the last twenty years.

The very fact that these things are used in multiplying goods, proves that they inhere in the goods, as type inhere in their impressions, and make every impression an original.

Rex v. *Watson*, 2 Starkie, 130.

There was no need of such an order till such business systems were introduced.

The following destruction orders have been issued:

Betts v. *De Vitre*, 34 L. J. (ch.) 289. This was the capsule case. The metal ordered destroyed was a compound foil of lead and tin, technically a "rolled plate," which required no other tools to make it than the ordinary rolls of a lead works, and the capsules to be destroyed were simple cups of this metal, made by the ordinary drawing stamps and dies of a sheet metal factory.

Badische Anilin and Soda Fabrik v. Levestein, L. R. 24, Chy. D. 176:

The material pursued was the product of a chemical process, resulting from the treatment of a coal tar product with commercial reagents. The patent was for the method of treatment and for the result. No special tools were required.

Price Pat. Candle Co. v. *Baumen's P.C. Co.*, 4 K. & J. 727, proceeded on a patent for a chemical process and product. The destruction order prayed applied to the product only. The machinery was ordinary machinery, vats, pumps, &c.

Plimpton v. *Malcolmson*, see L.R. 20, Eq. 37:

The patent was for parlor skates. Malcolmson's skates were made by contract. He was not a manufacturer, but a dealer and lessor.

The following injunction orders to run after the expiration of the patent have been granted:

Crossley v. *Derby G. Light Co.*, 4 L.J. (N.S.) Ch. 25:

This order was granted by Lord Brougham. It was before the day of special tools. It was granted against a concern which was making the goods for its own use, not for sale, and against a machine that could have only a few sheet-metal templets worth a few shillings a set, as specialties for construction. The relief now prayed would have been in the nature of a *scintilla juris*.

The *Diamond Drill* cases involved only drill heads

in the hands of users, not in the hands of makers, and required no such order.

The machinery of the barrel pitching case, *Gottfried* v. *Moerlein*, 14 Fed. Rep. 170, was a fan blower, a charcoal fire, and a pipe. It was enjoined in the hands of a user.

The harvester case, *Toledo Mower and Reaper Co.* v. *Johnston Har. Co.*, 24 Fed. Rep. 739, is the only one which on its face seems to be a likely case for such a motion.

But a reference to the patent of John L. Davis, No. 75, 383, March 17, 1868, discloses that the patent was for a re-arrangement of old parts, so that it is doubtful if such a motion as this could fairly have been made.

Besides, disabling all the unlawful machines and parts of unlawful machines, and ordering their destruction or delivery, would be, in a business way, very ample business relief, by locking up the quick capital of a rival concern in unsaleable goods, so as to eliminate competition or handicap it by an unforeseen interest charge.

In injunction cases in which the patents are still alive, the things to which attention is called here become useless and uncared for, and either by natural decay, by purposeful destruction, or by delivery, are practically eliminated during the life of the patent.

Since, then, the circumstances of a patent case never needed such an application before, the lack of precedent for it has no weight.

ANALOGIES.

The injunction desired has analogies in preventive relief sanctioned by precedent, and granted against the persons and things who might be called indirect infringers, and indirect infringements, but who would have better legal definition if they were styled privies of infringement *in persona*, or *in re*, or better, participants of infringement.

Such are owners of infringing machines who do not run them: persons who prepare for an infringement and let others take the last and final step, which all acknowledge to be wrong; and the like.

In *Woodworth* v. *Edwards*, 3 W. & M. 121, the owner of a machine, who had neither built nor operated it, was enjoined.

In *Wallace* v. *Holmes*, 9 Blatch. 73, 1 Off. Gaz. 117, 5 Fish. 37, the maker of one part of a patented combination, a burner, which was claimed only in combination with a chimney, was held to be an infringer and liable to injunction, and held to an account.

The principle of this case was adopted and followed in the skate accounting of *Turrell* v. *Spaeth*, 8 Off. Gaz. 986; also in *Boyd* v. *Cherry* (Iowa) by Judge McCrary, a process for raising cream, held infringed by sale of apparatus, with instructions how to use.

In *Richardson* v. *Noyes*, 10 Off. Gaz. 507, a similar rule was applied to the maker of standards for

carriage tops, which were to be built by others into a clearly infringing combination.

In *Rumford Chemical Works* v. *Hecker*, 2 Ban. & Ard. 363, mixing acid phosphate and bi-carbonate of soda with flour and selling it was held to be the use of phosphoric acid, or acid phosphates, when employed with alkaline carbonates, as a *substitute for ferment or leaven in making bread.*

In *United Telephone Co.* v. *Dole*, L.R. 25, Ch. D. 778, it was intimated by PARSONS, L.J., that sale of the component parts of a patented machine for others to put together would be infringement.

In *United Telephone Co.* v. *London & Globe Telep. & Maintenance Co.*, L.R. 26, Ch. D. 773, defendants were in possession of Blake transmitters lawfully made beyond the seas, imported into England, never used by defendants, sold to them under a contract that they should be "royalty paid," but which in fact were not "royalty paid," and which had been taken to pieces by defendants and all the infringing parts removed. The case was prosecuted because defendants declined to export the machines or destroy or deliver up the removed parts. Injunction granted against making, using or selling the machines, but no order as to destroying or delivering up the parts, which defendants had argued they might use in a lawful way (p. 773).

Sykes v. *Howarth*, L.R. 12, Ch. D. 826, is to the same point.

The principle of all these cases may be that the

person held as an infringer is a joint trespasser, who is responsible for the whole damages.

But as the element of intent by the manufacturer or vendor, that the component parts of the patented combination, made or sold by him shall be used in the construction of infringing goods, is *essential* to responsibility in a patent trespass (*Bowker* v. *Dows*, 3 Ban. & Ard. 518; *Saxe* v. *Hammond*, 1 Hol. 459), and as also it is essential that the thing shall be comparatively useless, unless assembled with the other parts of the patented combination (*Maynard* v. *Pawling*, 5 Ban. & Ard. 551; *Millner* v. *Schofield*, 4 Hughes, 261), this hardly seems a sufficient explanation.

Against this view are two rulings. In a set form of words, the Circuit Court in Massachusetts has held "Infringement is not a trespass."

United Nickel Co. v. *Worthington*, 23 Off. Gaz. 939, 13 Fed. Rep. 294.

Where two men conspired to infringe a patent and distribute the goods,—one a maker, the other a seller, — the manufacturer giving bonds to defend a suit against the seller, and this after suit was brought,— and also conducting the defence, and also agreeing by bond to pay the damages recovered,— on the sole condition that the seller should go on selling,— this same court held that the license fee which measured the damages could not be assessed against the seller for any goods that had not passed through his hands.

McDonald v. *Shepard.*

Hence it seems that the doctrine of joint trespass is not fully applicable to this subject matter, nor, by consequence, explanatory of the cases cited on combinations infringed by sale of parts.

But the doctrine of all the cases is consistent and reconcilable, on the principle that to make, use, or sell an essential of infringement, useful for no other, or scarcely any other purpose, intended and created for the prosecution of infringement, is in itself an infringement.

Upon this doctrine, and probably only on this, may be supported the law of Judge LOWELL's judgment in *Starrett* v. *Athol Machine Co.*, Dec. of Com. of Pat., 1883, 255.

The Athol Machine Co. had leased its power, machinery, &c., to its co-defendants for two purposes, one to carry on the regular business of the Athol Machine Co., and the other to do the manufacturing for the Standard Tool Company. The profits of the Athol Machine Co's. business were to be shared in agreed proportions, and the Athol Machine Co. was to have 10 per cent. of the net receipts of the Standard Tool Company's receipts, as rent. The co-defendants were the lessees, and made try-squares which infringed a patent. Judge LOWELL said:

"The fact that they receive ten per cent of the net sales by way of rent does not give them such an interest in the try-squares or in the business that they are responsible for the profits of the manufacture. The plaintiff insists that the whole contract is a device

to shield the Athol Company as infringers. But this is not proved. There is, however, some evidence tending to show that the company *have made tools for the express purpose of manufacturing these try-squares*, and perhaps that they made a few squares before the contract with Newton & Bellows went into effect. Besides, I am not sure that a landlord may not be enjoined from permitting his tools and machinery to be used for the injury of a third person, if he has any power to prevent it. I think an injunction should go against all the defendants; but when it comes to an accounting, the plaintiff must prove before the master that the company is liable in profits and damages, under the risk of what the court may order concerning costs."

SUMMARY.

Should, therefore, this Court be of opinion —

1. That the patent for making, using and selling these valves has been infringed;

2. That the *making* of the patent law includes each and every step, from the working drawings, to the finished article;

3. That every surviving part of the making, done during the term of the patent, is enjoinable;

4. That the *selling* of the patent law includes solicitation of trade by a salesman or by a circular, when not successful as well as when successful;

5. And that every surviving part of the *selling*, done during the term of the patent, is enjoinable.

All which five propositions we claim as law, —

Inasmuch as this Court has, without argument, intimated against the rule in the former case on these patents: —

HOW TO REACH THE RESULT DESIRED.

The Court is desired to define the limits to which an injunction may go, in conformity with the law, and insert in the mandate a direction to the Court below, to order an inquiry by the Master as to whether the defendant now has in his possession or under his control, any drawings, patterns, special tools, cuts, circulars, letter-press, existing during the term of the patents in suit, or mechanical reproductions or copies thereof, or any valves or parts of valves so made, designed and intended for use in making or selling such infringing valves; and if so, to report what they are; and to issue an injunction against further use thereof by defendant, or copying the same, and that the same may be delivered up or destroyed under supervision of an officer of the Court; as well as the usual order for account.

Such an order of inquiry was granted by V. C. Page Wood, in *Price Pat. Candle Co.* v. *Baumen's P. C. Co.*, 4 K. & J. 727, where the patent had expired pending the litigation, in order to hold the defendants, if possible, to an accounting, when the accounting was ancillary to an injunction only.

THOS: WM: CLARKE.

SEPTEMBER 14, 1886.

119-425

Office Supreme Court U. S.
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JAMES H. MCKENNEY,
CLERK.

Supreme Court of the United States,

THE CONSOLIDATED SAFETY VALVE COMPANY

vs.

ERASTUS B. KUNKLE.

OCTOBER TERM, 1885. No. 155.

Appeal from the Circuit Court of the United States for Northern District of Illinois.

APPELLEE'S BRIEF.

JAMES H. RAYMOND,
Solicitor and of Counsel for Appellee.

Mrs. M. Wiggins, Printer, Room 68, 143 LaSalle St.

Supreme Court of the United States,

OCTOBER TERM, 1885.

CONSOLIDATED SAFETY VALVE COMPANY

vs.

ERASTUS B. KUNKLE.

APPELLEE'S BRIEF.

[NOTE.—The page references herein preceded by S. are to the stipulation at the end of the record.]

STATEMENT.

This is a suit in equity, commenced October 6, 1880, by appellant in the Circuit Court for the Northern District of Illinois, against E. B. Kunkle, a manufacturer in Indiana of safety valves under, "but not in strict accordance with" (p. 11) Letters Patent, granted to him in 1875 and 1877. Plaintiff sued under Letters Patent granted to George W. Richardson September 23, 1866 (No. 58294) and January 19, 1869 (No. 85963).

Plaintiffs' patents have both expired. An injunction *pendente lite* was denied, as stated below, and the bill on final hearing was dismissed by the Circuit Court. This suit has therefore become simply a suit to recover back damages for alleged infringements by a subsequent patentee who is manufacturing under his own patents.

The bill does not contain any specific alllegation that the two patents sued upon are capable of being embodied in the same manufactured article or that they have been in fact so embodied by defendant, as is required specially by many decisions of the courts rendered since this bill was filed. It is, however, true that this point of multifariousness was not raised by any pleading by defendant and can now only be raised by the court *sua sponte*.

Upon motion for an injunction *pendente lite* the Circuit Court required defendant to give bonds in the penal sum of *three thousand dollars*—otherwise the injunction to issue.

manufacturing spring-loaded safety valves for locomotive or other engines; and, if so, how frequently?

Ans. We made about one hundred locomotives—ninety-seven or ninety-eight—between 1852 and 1857, all of which had two spring-weighted safety valves; that, I believe, is all.

Cross-int. 16. To what pressure were these spring-loaded valves adjusted?

Ans. The pressure was up to 130 pounds to the square inch.

Cross-int. 17. Do you remember what length of lever and what proportions of leverage were used in these spring-loaded lever safety valves?

Ans. Not distinctly. We bought spring balances in the market; generally used two in combination at the end of the lever, and made new dials to correspond with the leverage. I should think the lever age would be about five to one.

Cross-int. 18. Do you remember what extension of spring corresponded to a pressure of 130 pounds?

Ans. Well, my recollection of the size gauge, as I remember it—length of its scale—three and a half or four inches.

Cross-int. 19. Do you mean three and a half or four inches for one spring?

Ans. For each spring; two springs were placed back to back and used in combinatien. Of course, the proportion would be between the total lift upon the valve (the area acted upon by the pressure, and the pressure acting upon that area are factors in the total lift); and this total lift, in combination with the relative length of the two arms of the lever, determined the scale of the spring balances.

Cross-int. 20. Then, as I understand you, in order to hold down 130 pounds pressure in the boiler, by a leverage of 5 to 1, you employed a pair of springs, which were extended from $3\frac{1}{2}$ to 4 inches in their adjustment?

Ans. Yes, I think so.

Cross-int. 21. Did you make any observation on the usual
259 spring-weighted safety-valve of that period so as to be able to say whether or not this was the usual spring at that period?

Ans. Not definitely. I have the impression that I saw such springs in use—very similar to those—on locomotives built by other builders.

Cross-int. 22. Now, as a mechanic, if you were to substitute a direct-acting spring for this spring at the end of the lever so as to get on the direct-acting spring a corresponding amount of compression to the amount of extension on the spring at the end of the lever, due to the leverage, the corresponding compression of a direct-acting spring at that pressure would be $1\frac{2}{5}$ or $1\frac{3}{5}$ of an inch, would it not; if not, what would it be?

Ans. It would be from $\frac{7}{10}$ to $\frac{75}{100}$ of an inch. The two springs acting in conjunction acted as one, and might have been replaced by one. Only one would have been used, but for the convenience of buying scales ready made. Then, as the leverage was about 5 to 1,

the amount of compression on a single spring acting directly upon the valve would have been about $\frac{1}{5}$ of $3\frac{1}{2}$ to 4 inches, which, as I should have said, would be $\frac{7}{10}$ to $\frac{8}{10}$ of an inch.

Cross-int. 23. Do you consider it to be the duty of an expert in testifying in a patent cause to construe the letters patent for the benefit of the court?

Ans. I consider it to be his duty to construe them truly, without special pleading, concealment, or prevarication.

Cross-int. 24. That means you do consider it his duty to put a construction upon the letters patent, do you?

Ans. Unquestionably so. I say, after some reflection, so far as they describe, or purport to describe, mechanical devices or combinations to produce a specific result.

Cross-int. 25. In using the language of your last answer, beginning with "so far as," do you mean to narrow or enlarge the meaning of the word "construction"?

Ans. I mean to define the meaning; and, etymologically, I suppose to define is to limit. Yet, I should be sorry to limit the sense of my answer to the exact words I used. A patent is supposed to be addressed to persons skilled in the art to which it relates.
260 To all such persons it must be intelligible, and it is not necessarily intelligible to any other. An expert, professing to be skilled in the art to which the patent relates and that he is questioned about, ought, I think, to explain the patent as it appears to him, being so skilled, in such language that it may be understood by those without the special skill involved; and whatever is necessary to such explanation or interpretation of a patent, it seems to me to be his duty to give when asked to do so, as I said, without special pleading, reservation, or prevarication.

Cross-int. 16. When did you first become acquainted with spring-loaded safety valves having the capacity of lifting when a predetermined boiler pressure was reached, of discharging the excess of boiler pressure, and of automatically closing at a slight reduction from boiler pressure at which such valves opened?

Ans. If I do not mistake the purport of the question, the description of the valve given in the question is circumlocution for a "pop" safety valve. If I am right, I answer, I first observed the operation of a pop safety valve about 1869 or 1870, possibly as early as 1868, soon after I returned to Lawrence from New Bedford. Its prompt, decisive mode of opening and closing attracted my attention I watched it, inquired about it; I think I went to the car-shop of the Boston & Maine railroad to inquire particularly about it; possibly, however, I met the master-mechanic of that road in Lawrence, and inquired of him then.

Cross-int. 27. Was this faculty of prompt opening and closing, with but a slight reduction of boiler pressure between the opening and the closing, and without any considerable rise of pressure while the valve was blowing, anything new to you in the operation of safety valves, in the year 1868, as a practical experience?

Ans. The feature which was new to me and attracted my attention was the prompt opening and closing. I think I had made

safety valves myself before that date which performed the other functions reasonably well; but there was a little indecision about the closing, and, less noticable, about the opening. Two nearly balanced forces seemed to contend a little while for the mastery before one or the other gained it; and there was a period of in-
261 decision shown by leakage at the joint. The worst effect of this leakage was cutting out the seat of the valve in streaks, so that the valve required frequent regrinding to keep it tight. The prompt opening and closing which I noticed struck me as largely obviating the troublesome cutting action. It was that that was new to me and attracted my attention. I did not so much as inquire how much the pressure was reduced in the boiler before closing, that I remember.

Cross-int. 28. When, after this year, 1868, did you make any further investigations into the construction of pop safety valves?

Ans. I think about two years ago last March, say March, 1879, when I made special investigations for the purposes of a suit in which I was engaged as expert witness for the defence.

Cross-int. 29. Between 1868 and 1879 had you used any pop safety valves upon engines of your manufacture?

(Objected to, as immaterial.)

Ans. Yes, sir, a good many; the first one in October, 1877; I telegraphed from San Francisco for it, and had it sent on by express. I afterwards used quite a number in my manufacture of engines.

Cross-int. 30. From whom did you obtain your first pop safety valve?

(Objected to as incompetent and immaterial, and not proper on this cross-examination.)

Ans. From the Crosby Steam Gage & Valve Company.

Cross-int. 31. You have used the Crosby Steam Gage & Valve Company's valves on most of the engines of your manufacture or furnishing, have you not?

Ans. Yes; since I first used it.

Cross-int. 32. Did you, in the valves which you say you have had constructed according to the Ritchie patent, follow the size or proportions of parts represented in the drawing of that patent?

Ans. I don't remember that I have spoken in my testimony in this case of a Ritchie valve; that is, of having constructed or experimented with a model, according to the construction of the Ritchie valve.

262 Cross-int. 33. Are these words which I read you from the 18th manuscript page of your deposition in this case, words used by you in testifying in this case: "I have had safety valves constructed according to this Ritchie patent, and have experimented with them"?

Ans. They are down in my deposition in this case; they relate historically to experiments made more than a year ago, and were given to state my knowledge of the Ritchie valve, the experiments not being detailed in my deposition in this case.

Cross-int. 34. Were the safety-valves which you said you had constructed according to this Ritchie patent, valves which, in their dimensions and proportions of parts, followed the drawings of the Ritchie patent, or were they valves which varied from the drawings of the Ritchie patent?

Ans. They did not servilely follow the drawings of the Ritchie patent, but contained every feature described and shown by Ritchie, combined according to my best skill and judgment of the circumstances of the particular case to which I applied the valve I had so constructed.

Cross-int. 35. Will you please inform me if any part of the skill and judgment used by you in proportioning and adjusting and working the Ritchie valve, as you call it, was acquired by you, in any degree, subsequent to the time when you had your first conversation with the master mechanic of the Boston & Maine road, in 1868, about pop safety valves?

Ans. I cannot say that it was not, though I honestly tried to embody the essential features of Ritchie's valves without the admixture of subsequently acquired knowledge. In this connection, I would say that I never saw a patent drawing, to my recollection, which was a useful working drawing, and I never attempted to copy a patent drawing in all its features of inadvertence, of ignorance and of inattention, except in cases where I have had valves made to be put in as exhibits in this case, and have experimented with them; but that in this case I have followed the drawings with the utmost servility, even to their accidents and imperfections, to avoid the intermixture of any subsequently acquired knowledge. In
263 referring to the Ritchie valve historically, I merely said, I believe, that it opened in the manner Ritchie described. That is strictly true.

Cross-int. 36. What do you mean by a stricture?

Ans. I adopt the definition given by Mr. Richardson in the preliminary portion of his patent of 1869, and I believe that definition seems to have been conformed to by all competent expert witnesses who have testified on the subject, so far as I know. "My said invention relates to improvements in the invention described in letters patent granted to me, and bearing date twenty-fifth day of September, 1866, which said patented invention relates to a means for providing a more free escape for the steam that can be obtained by safety valves as constructed prior thereto, and to insure the keeping of the valve open until the pressure of steam in the boiler or generator falls below the pressure which was required to open it, the said means so patented consisting in forming the valve with a surface outside of the ground-joint for the escaping steam to act against, the said surface being surrounded by a projecting or overlapping lip, rim or flange, leaving a narrow space for the escape of the steam when the valve is opened, but which, although of greater diameter than the valve seat, by reason of the said lap, presents a less area of opening for the escape of steam than is produced at the valve-seat, so that the steam which escapes through the area between the valve shall exert pressure against the said surrounding surface, and thereby

not only open the valve completely, but hold it up until the pressure of the steam in the boiler falls below the pressure by which the valve was opened." This seems to me to be a complete definition of a stricture as the word has been applied in Mr. Richardson's valve and other safety valves; namely, an opening between an overlapping lip and an adjunct part, outside of it or inside of it, such opening, by reason of the overlap, having a less opening for the escape of steam than is produced at the valve-seat, although extending beyond it, is of greater diameter.

Cross-int. 37. Do you consider that with a valve having an extended surface outside of the ground-joint there is any relation of area material to the operation of the valve, except that of the area of the main steam-way and the area of the steam surface after the
264 valve has lifted? And if you do consider that any other area is of importance, tell us what area is of importance, and why it is of importance, and how such area could affect the operation of the valve.

Ans. I do not know of any other area, and cannot conceive of any other area, than is completely covered by the two areas described; namely, the one within the ground-joint or cross-section of the steam-way, which is acted upon by steam pressure when the valve is seated; and, secondly, the annular area outside of said first-described area, and within the extreme boundary of the projecting flange or lip; speaking, of course, with reference to the Richardson valve. That is, I cannot conceive of any other area as influencing the action of the valve by the pressure or impact of steam upon it. There is, however, another area equal, or about equal, to the whole area within the extreme boundary of the lip, namely, the area of the upper surface of the valve, which I have found to be powerfully acted upon by a partial vacuum produced over it through the agency of escaping steam acting like an ejector. This, however, is not the case in the Richardson valve, so far as I have observed.

Cross-int. 38. Now, inasmuch as my question was not confined to the Richardson valve, will you please answer it with regard to valves having extended surfaces outside the ground-joint generally, as it was put?

(Cross-int. 37. was again read to witness.)

Ans. Upon rehearing the question, I extend my answer to all valves having extended area outside of the ground-joint, after the manner of the Richardson valve. But as the question seems to relate to proportions, I have found experimentally that the proportions between the area within the circle of the ground-joint, and that which is without said circle but within the boundary of the lip, may be varied very widely with equally good results; and I cannot see that any fixed proportion between these areas is important to the operation of such a valve. I mean in cases where the lip surrounds the part forming the other border of the stricture, the inner border of the rim or lip; in cases where the rim or lip
265 is surrounded by the part forming the other border of the stricture, I mean the outer circumference of the lip.

Cross-int. 39. I understand you to say that the result of your

experiments is that with the same spring, the same stricture, and the same initial steam-way, you can vary the relation between the area of the initial steam-way and the area outside of it, and within the stricture, within certain pretty large limits, without changing the operation of the valve; do you mean this?

Ans. I don't think I said, at any rate I didn't mean to say, anything of the kind.

Cross-int. 40. Do you mean that with the same spring, the same initial steam-way, the same initial pressure of steam, and with different proportions between the area of the initial steam-way and of the surface inside of the stricture, you can get the same results in the operation of the valve; and, if so, how do you get them?

Ans. Yes; I answer the question affirmatively, and will explain with reference to my experiments with the Webster valve in this case. There was but one spring used in this case. It has a fixed steam-way for the action of initial pressure upon the valve. During my experiments the pressure was kept at a uniform point, namely, 100 pounds per square inch, and the area outside of the steam-way and within the outer border of the lip, and also the area within the outer border of the steam-way, were all fixed, and bore constantly the same relation to each other and the spring; yet I did practically obtain, with an initial lifting pressure of 100 pounds, a reduction ranging from 1 pound to 17 pounds, by merely varying the height of the Webster regulating flange precisely in the manner he indicates in his patent. These experiments were repeated over and over again, and were perfectly uniform and definite. For instance, when set to close with 1 pound reduction, the pop was sharp and clear at 100 pounds, the closing equally distinct and uniform at 99 pounds. And the same was true of other degrees of reduction—2 pounds and 17 pounds; and I am certain that it could be set with absolute certainty for every intermediate pound between 1 and 17, and this without varying the stricture at all, but by simply varying the amount of obstruction which the more or less circuitous path
266 through the strictures caused, by setting the flange at a lower or higher point, produced upon the escaping steam.

Cross-int. 41. Now, will you please tell me what I asked you in the last question; whether, with a valve having a given initial area to the steam-way, a given strength of spring, a given amount of steam pressure, and an extended surface, the extended surface can be varied, keeping the other things constant, and produce the same work in the valve; and, if so, by what means you do it?

Ans. If you should vary one part without varying the others in proportion, you certainly would disarrange your combination; and I am apprehensive if I undertook to vary Mr. Webster's drawing, I might be suspected of introducing subsequently acquired knowledge. At the risk, however, of being betrayed into the exhibition of some subsequently acquired knowledge, I think considerable increase or diminution of the ratio of supplemental area to initial area could be made, while retaining the use of the same spring and the same relative open area of stricture, with equally good results, by merely varying the depth of overlap, a variation which Webster seems to

contemplate, even to an extreme degree, by saying that "the flange may be set down so as to rest on the valve as though it were solidly a part of it."

Cross-int. 42. Do you understand that I have put you any question yet about the Webster valve?

Ans. Not directly.

Cross-int. 43. Why, then, have you imported that valve into your answer?

Ans. Simply because in that way I was able to give facts instead of opinions.

Cross-int. 44. What is the effect of the overlap of the two parts of the valve and valve-seat, between which is formed the stricture; is it not to impede the progress of steam to the open air?

Ans. Yes; that is one effect. There is another, and a very important one, and that is that the actual size of the stricture remains unchanged, while the opening at the ground-joint goes on increasing as the valve rises, until the overlap is surmounted, whereupon
267 the stricture begins to widen. The effect is that while the quantity of steam escaping from the boiler into the intermediate chamber goes on increasing, the quantity escaping out of it to the air increases very slightly, and that by reason of the increased pressure within the intermediate chamber itself. The action of the overlap may be illustrated in this way: If you have a passage for steam with parallel sides, with a bottom fixed to the sides and a top pivoted to the sides at the outlet end of the passage, the area of the passage for final escape at the outlet would remain unchanged, while the cover at the other end was lifted up between the parallel sides so as to greatly enlarge its capacity at the inlet; and this would exactly resemble the action of an overlapping stricture. If, on the other hand, you had a similar passage with the cover pivoted at a point representing the centre of the steam-way, and there pivoted so closely to the bottom that there should be no escape of steam between the cover and the bottom, and should then lift the outer end of the cover, so that at a point from the hinge which should represent the inner edge of the ground-joint, and the lift of the cover should represent the lift of the steam valve at the ground joint, then at a point further out from the hinge it would represent the position of the rim, lip, or flange—the opening under this hinged cover would represent the opening at the lip. That is, in the latter case it might have been, originally, that the stricture would open so much faster than the ground-joint, because of its greater radial distance from the hinge, that it would immediately cease to be a stricture at all; while in the other case with the overlap the stricture retains its distinctive characteristic; that is, it remains of smaller area than the open area through the ground-joint.

Cross-int. 45. Do you mean by all that that the overlap of the two parts which forms the boundaries of the stricture do not have a tendency to impede the passage of steam to the open air?

Ans. No, I do not mean that. It has such a tendency as I distinctly said in a previous answer.

Cross-int. 46. I notice that you say, on the 25th manuscript page

of your deposition, "I have made numerous accurate experiments with safety valves, made with the utmost exactness after the
268 patent drawings of Webster, Hartley, and of Waterman;" do you intend to have that statement stand as your description of the valves that you tried experiments with in this case?

Ans. I do.

Cross-int. 47. The Waterman valve which you tried you fitted up with a direct-acting spring over the valve, did you not?

Ans. Yes, there is a direct-acting spring over it; that, however, forms no part of Waterman's patent.

Cross-int. 48. The Waterman patent as it existed prior to 1866, before its reissue, described a lever and weight and a dash-pot as a means of weighting the valve, did it not?

Ans. That was a part of the contrivance connected with his valve, a part of it upon which he had a patent; upon the reissue, however, he obtained a patent for other features shown but not claimed in the original patent.

Cross-int. 49. Will you please tell me why, in your experiments with the Waterman valve, you did not fit it up and weight it as described in the Waterman patent?

Ans. Because I could not see that it had any reference to this feature of his invention.

Cross-int. 50. If you had conceived it had any relation to this feature you would have tried it, wouldn't you?

Ans. Yes, I presume I should. If levers, weights, or springs had been in any way concerned in this case, I should certainly have tried it.

Cross-int. 51. The Hartley valve which you tried had a direct-acting spring over the valve, had it not?

Ans. It had.

Cross-int. 52. It was enclosed in a case not represented in the Hartley patent, was it not?

Ans. Yes, I believe it was.

Cross-int. 53. The Hartley valve shown in this drawing had a weight suspended within the boiler, did it not?

Ans. That is one form he shows, and entirely competent for him to show.

Cross-int. 54. Did his drawings show any other form?

269 Ans. I do not think they did, as his patent did not relate to them in the least.

Cross-int. 55. Now, coming to your Webster valve, so called, what was the compression of the spring in that valve for 100 pounds pressure?

Ans. Eleven-hundredths of an inch.

Cross-int. 56. Why did you not use the spring having a compression of from one-fourth to three-tenths of an inch instead of eleven hundredths of an inch?

Ans. I had no occasion to, because the present one answered very well. If I had found it desirable I should have changed.

Cross-int. 57. Was this spring with this compression of eleven hundredths of an inch the first spring which you tried?

Ans. Yes, sir; the only one which I tried?

Cross-int. 58. When did you come to the conclusion that a spring having a compression of eleven-hundredths of an inch was a suitable spring to use with the valve of the proportions you adopted in your experiments with the Webster valve?

Ans. On the eleventh day of October, 1881.

Cross-int. 59. Had you before that time made any experiments with, or calculations upon, the strength of spring required under the circumstances in which you proposed to use the Webster valve in this case?

Ans. Yes, I have made such calculations.

Cross-int. 60. When did you make such calculations?

Ans. The first time I recollect making such calculations was just before giving an answer in a previous suit to a cross-question by counsel for complainants in this case, on the 17th of May, 1880. About that time I had made some calculations, the results of which were embodied in an answer which I will not quote unless I am required, because it is rather long, but will refer to it as the answer to cross-interrogatory 97, pages 168 and 169 of the record in the case "Consolidated Safety Valve Co. *v.* Crosby Steam Gage & Valve Co., U. S. circuit court, district of Massachusetts, in equity."

Cross-int. 61. And in that case you said on that day, did
270 you not, that you were not aware that any such spring was ever actually used, and that you had no idea that any spring in common use could be successfully applied in the manner indicated by the counsel?

Ans. Yes, I find I said something very like the language quoted in the question.

Cross-int. 62. From your calculations in that case, you came to the conclusion, did you not, that the increase of additional area, compared with the area of the steam-way, required you to use in such a case of increase a spring of greater strength than where the additional area bore a less ratio to the area of the steam-way?

Ans. Yes, other conditions being the same; but the opening of the stricture is another condition. Taking Webster's drawing and trying to closely copy it, I had to copy the area of stricture as well as the supplemental area and additional area. Now the width of stricture in the Webster drawing is so great that the pressure in the intermediate chamber under the supplemental area must obviously be a great deal less than that required to lift the valve from its seat; and unless the stricture and all other conditions are also fixed, the variation of the spring, depending on the variation of the ratio inquired of in the question, would not strictly follow.

Cross-int. 63. As I understand you, having a safety valve with a given area of supplemental surface, a given area of initial surface, a given stricture, and a given spring which works just right, you can preserve the size of the stricture, the size of the initial area, and change the size of the supplemental area, and make a new valve work just the same by changing the spring and putting in a new spring properly proportioned to the new ratio between the initial and supplemental area, can you not?

(Question objected to, as incompetent and immaterial,)

Ans. Yes, I presume so.

Cross-int. 64. And from such given factors you have calculated the proper strength of spring, have you not.

Ans. I have, for certain given cases and given conditions, within certain reasonable limits, so calculated them.

271 Cross-int. 65. And you have done that calculation by a rule of proportions, have you not?

Ans. Not by the simple rule of proportion. The variation of pressure in the intermediate chamber, attendant upon certain various widths of stricture opening, would be an intricate problem, and would depend again upon the overlap; but the variations to be produced by the variations of the overlap would be held in reserve for adjustment.

Cross-int. 66. Now when did you discover this involved intricacy of propositions?

Ans. Well, in the course of the education I derived from my cross-examination in the Crosby case.

Cross-int. 67. And that was since the year 1879, was it not?

Ans. Years 1879 and 1880, probably.

Cross-int. 68. Will you tell me how deep the lower edge of the flange, in the Webster valve with which you have tried experiments, was immersed in the casing which surrounded said flange, and between the inside of which and the outside of the flange the stricture was formed, in the experiments in which said flange was immersed deepest in the casing?

Ans. With pleasure. Four and a half one-hundredths of an inch.

Cross-int. 69. This immersion gave you a loss of eighteen per cent. of your pressure, did it not?

Ans. A loss of seventeen per cent. of the pressure. It varied from seventeen to eighteen at different times, probably because the adjustment varied slightly.

Cross-int. 70. Now you have said, I believe, that this Webster valve was made in accordance with the drawing, Fig. 3, of the Webster patent, have you not?

Ans. I have.

Cross-int. 71. And I think you used the words about it, "with the utmost exactness," did you not; and also the words, "Chinese fidelity," did you not?

Ans. Perhaps I did. I used it on a former occasion; I don't remember when.

272 Cross-int. 72. Now will you please tell me what the amount of immersion in the case of overlap is, as represented in the drawing, Fig. 3, of the Webster patent?

Ans. From one-half inch to nothing. The wall around the valve being one-half inch high for provision for an adjustment, the direction is to adjust at any height you please.

Cross-int. 73. Are you incapable of measuring the depth of overlap shown in that drawing, or do you mean to be understood that,

as shown in that drawing, the overlap varies in the same drawing from one-half inch to nothing at all?

Ans. I can measure anything measurable tolerably well. All that is shown in the drawing is a momentary adjustment, particularly specified, and subject to variation at pleasure. The adjustment as shown exhibits an overlap of about eight one-hundredths or nine one-hundredths of an inch. Nothing is said about the stiffness of the spring, as it was none of his business. Nothing is said about the steam pressure to be carried in a boiler, as it is presumed he designs his safety valve for all practicable pressures. Nothing is said about the proposed reduction of pressure, that being properly left to the designer and user of the valve.

Cross-int. 74. In your experiments, knowing that Mr. Webster's momentary adjustment illustrated in his drawings was eight one-hundredths or nine one-hundredths of an inch overlap, you carefully avoided using an overlap of more than half this larger measure that you have mentioned; did you not?

Ans. No; I didn't think of it. It never occurred to me to think of such a thing. When he tells me that the collar or flange may be brought down on the stem so as to rest on the top of the valve, it never occurred to me that he meant, or anybody could intend, that I should follow the momentary adjustment in his drawing; if it had, I certainly should have tried it.

Cross-int. 75. You did stop in obtaining your overlap at three and one-half one-hundredths to four one-hundredths of an inch short of the point Mr. Webster has shown, didn't you?

Ans. I did, and I therefore did not develop the whole range of adjustability in the Webster patent.

Cross-int. 76. If I understand your position upon this sub-
273 ject, the reason that you so stopped was because the Webster patent invited you to make a valve with a greater overlap by bringing the sliding collar down on the stem so as to rest on the top of the valve; am I correct?

Ans. The question contains a partial and incomplete statement of the Webster invention. The Webster adjustment is not alone for increasing the amount of reduction by lowering the flange. It is broader than that. It is for regulating the amount of reduction by adjusting the flange. Because of that I adjusted just as I pleased for my purpose, its parts having been copied in servile imitation of a diagram which probably never before was dreamed of as a working drawing and never will be again, and those parts adjusted precisely as he directs. I made the adjustment to suit myself without any reference to whether he intended I should use 100 pounds pressure or 50 pounds pressure, five per cent. reduction of pressure or fifty per cent. reduction of pressure; without reference to anything, but to take the advice he illustrates by a diagram and describes in words, so copying it as to show that I did not introduce any subsequently acquired knowledge. I adjusted it by his directions to me and the requirements of the case. The fact is that it operated as he said it would and did.

Cross-int. 77. Now, did you or did you not intend to give me as a

reason for not trying the amount of the overlap shown in the Webster drawing, Fig. 3, that Webster told you in his patent that the flange "may be brought down on the stem so as to rest on the top of the valve"?

Ans. No, not solely; but chiefly because he told me this:

"Upon the stem *c* of the valve I place a collar or flange, *e* (shown separately in elevation in Fig. 2); the said collar or flange *e* is capable of sliding on the valve stem *c*, and is fixed at the desired height by the screw *f*."

I therefore fixed it at the height I desired; and when I desired to fix it at any other height I fixed it over, and so on, at four different heights, I think. And I will cheerfully fix it at any height complainant's counsel desires, and report the result of the experiment, if requested to do so.

274 Cross-int. 78. Now, is not all you have quoted in your late answer from the Webster patent the description of the thing illustrated in the Webster drawing, Fig. 1?

Ans. It is equally applicable to Figs. 2 or 3 so far as adjusting the cover is concerned, and even with greater range of adjustability in Fig. 3 than in Fig. 1. He says with regard to Fig. 3:

"I sometimes make the sliding collar or flange of less diameter than the case or hollow cylinder surrounding the valve. This modification of my invention is represented in Fig. 3 of the accompanying drawing, where *h* represents the sliding collar or flange, capable of being adjusted to any desired height above the valve *k* in the interior of the case or hollow cylinder *i*."

Cross-int. 79. Was it because of the instruction contained in the words "in the interior of the hollow cylinder *i*" that you set the lower edge of the lip or flange very slightly above the upper edge of the encircling ring of the valve seat in your first experiment with this so-called Webster valve?

Ans. I set it so because I desired to, as Mr. Webster instructed me to. His instructions are, set it at any desired height above the valve, which valve, he says, is in the interior of the case.

Cross-int. 80. You then distinctly swear that the instructions which Mr. Webster gives you in the words "in the interior of the case or hollow cylinder *i*," in your best judgment, do not apply to the flange?

Ans. They certainly do not imply that the flange is always to be kept within the interior of the case, but when slid down it slides within the case. In the language of the patent, "*h* represents the sliding collar or flange, capable of being adjusted to any desired height above the valve *k*." This cannot be construed, in my opinion, without extreme violence, to limit the desired height by the height of the case. It does not refer to the case; it refers to the valve *k*. I set it no higher above the valve *k* than I desired to set it. There is where Mr. Webster instructed me to set it.

Cross-int. 81. When Mr. Webster gave you that instruction in his patent he punctuated it, didn't he, putting a comma after
275 the word "drawing," a comma after the word "flange," a

period after the letter "*i*," and no other punctuation from "drawing" to "*i*"?

Ans. He so punctuated it; no other punctuation.

(No cross-int. 82.)

Cross-int. 83. You have said that you have found that this valve, "Exhibit Defendant Webster valve," Fig. 3, "operates in that faultless manner in practical working in a manner which Mr. Richardson must be contented to emulate, but can never surpass," have you not?

Ans. I have, I believe.

Cross-int. 84. You have also said on the 17th of May, 1880, with regard to valves which had the ratio of compensation flange to the steam-way of 3.67 to 7, or 3.147 to 6, or 3.595 to 7.5, and retaining strength of spring, size of the stricture and overlap of stricture, such as you made it in experiments to reproduce the Webster valve prior to your testimony on the 17th of May, 1880, these words, "I shouldn't have been crazy enough to make such valves," have you not?

Ans. Yes, sir; I believe I used those words, properly enough in my state of knowledge at the time.

Cross-int. 85. Your state of knowledge on the 17th of May, 1880, at the time you made that answer, is a less state of knowledge with regard to automatic safety valves than your state of knowledge at your present testifying, is it not?

Ans. It is. I have gained some knowledge by experiments made since. I find that I also used the following language after the words "I shouldn't have been crazy enough to make such valves": "The Webster drawings would have served my purpose equally well had they been made with all that portion outside of the interior of the steam-way, exactly as in the drawings; and a steam-way itself one inch, two inches, or three, four, five, or six inches in diameter, or any diameter smaller than an inch or greater than six inches, or of any intermediate diameter, since proportion does not enter into them at all." And I now reaffirm that opinion, and reaffirm the fact that the Webster drawings show a mode of construction in which all details are disclaimed; a mode of construction applicable
276 to every practical pressure from the lowest to the highest, for every required size from the smallest to the largest, and for every form of loading, whether by springs above or springs below, by weights above or by weights below, by springs or weights acting directly, or by springs or weights acting through levers; and that during the life of said patent every conceivable proportion of parts, including Mr. Richardson's and all others, would have infringed said patent, provided, of course, that the adjustable flange of the Webster valve was retained.

Cross-int. 86. By your last answer I understand you to affirm that the operation of a spring-loaded safety valve is the same as the operation of a direct loaded safety valve with dead weight; or that the operation of a spring-loaded safety valve with a lever is the same as the operation of a dead-weighted safety valve with a lever; do you mean to be so understood?

Ans. No, not quite. Whatever differences there may be in the several forms involved in the question, all were equally available to every mechanic, whether inventor or not, being well-known equivalents, the one for the other, open to Mr. Richardson, therefore, who used them just as he pleased, and to every other designer of safety valves, to select from whichever he thought best adapted to his case in hand.

Cross-int. 87. Do you consider that in the working of a safety valve with an additional area outside of the ground joint, the dead weight and a spring are equivalents, so far as the reduction of pressure is concerned, at the time of closing the valve?

(Question objected to, as being incompetent and immaterial.)

Ans. Mechanical equivalents they are in a certain sense; not that their action would be exactly alike. I do mean, however, that all forms were equally available to the public, and open to selection and adoption at pleasure.

Cross-int. 88. When you say "mechanical equivalents," do you mean that they were of equal value with the same flange, the same expansion chamber, and the same stricture as regards the reduction of pressure in the boiler, or do you mean that they were of different values as regards such reduction of pressure, the values being
277 expressed in pounds' pressure, or percentages of the initial pressure in the boiler?

(Same objection made to this question as to the last.)

Ans. I mean that all were equally well known, and free to be used indiscriminately at the will of the designer. There would certainly be some differences in their action, whether with or without the supplemental area, and whatever proportions that supplemental area might have to the initial area. A weight doesn't increase in force of action by being lifted higher from the seat. A spring acting on a valve has its resilience increased by compression. There may be differences of a less striking kind between direct acting weights or springs and weights or springs acting through lever; but all were open and common ground, free to public use and not to be properly re-enclosed by combinations which do not introduce new and useful results, and it was through this common, public right of use that Mr. Richardson adopted such springs as he chose to adopt, without ever intimating, so far as I can learn, that he had invented a new combination thereby.

(The foregoing gush objected to by Mr. Clarke, as utterly irresponsive.)

Cross-int. 89. I understand your position then to be that on a given safety valve a dead weight and a spring are exactly equivalent as loads in every respect, including rise of pressure in the blowing of a valve and reduction of pressure in closing of the valve, whatever be the construction of the valve; is this what you mean to be understood?

(Same objection as to last question, and for the further reason that the question is leading.)

Ans. No, sir; I think I distinctly stated otherwise in my last answer, since I stated that a spring would have its resistance increased by compression when the valve is raised, while a weight would remain constant whether raised or not. What I mean is, that it was competent for any designer of a safety valve, patented or not patented, to choose with entire freedom any of these forms which, for any reasons or without reason, he prefers.

Cross-int. 90. Then I am to understand you, am I, without
278 circumlocution, to say that the spring and the weight are not the exact mechanical equivalents for each other upon a safety valve, as far as regards the opening of the valve and the rise of pressure while the valve is blowing? Please don't put anything more in this answer than, according to your best judgment, you think it absolutely necessary to give a categorical answer to the question.

Ans. I think that they are mechanical equivalents with some difference in their mode of action.

Cross-int. 91. Now, if they are exact mechanical equivalents, wouldn't a weight of a hundred pounds hung to the stem of "Defendant's Exhibit Webster Valve," Fig. 3, with the spring of that valve entirely removed, make the valve work in the same way as the spring compressed to eleven one-hundreths of an inch? for a pressure of one hundred pounds makes that valve work.

Ans. Yes, sir; with suitable modification of the other part of the valve. And I think it probable also without permanent alteration, with suitable adjustment.

Cross-int. 92. Do you find any directions for this work in Webster's patent; and, if so, what are they?

Ans. I find his patent to be entirely general and applicable to every possible size or form of safety valve. After describing various forms shown by the diagrams in this drawing, he says, in his claim, "I wish it to be understood that I do not limit myself to the precise details herein described and represented, as the same may be varied without departing from the nature of my invention." He says: "By adjusting the sliding collar or flange *e* to different heights on the valve-stem *c* the action of the steam upon it may be regulated." And taking the whole patent together, he claims a specific device consisting of a movable or sliding collar or flange adjustable on the valve-stem, so as to vary within certain desired limits the action of the steam in lifting the valve and holding it up; useful especially when a spring is used; but, by necessary implication, useful in general, even when a spring is not used. He says: "The valve *a* is pressed to its seat by a spring or weight on the prolonged end of said arm or lever *d*." So far as that is concerned, it is exactly
like Mr. Richardson's, which necessarily implies a lever, in
279 the use of the words "spring or scales." And again, the words, "for an ordinary spring or balance;" and again, "for a strong spring or balance;" and again, "for a weak spring or bal-

ance." Now the use of these words, "spring, scales, and balance," in Mr. Richardson's patent of 1866, points clearly to the existing state of the art at the time. These "springs, scales, and balances" were the ordinary spring-weighing apparatus sold in hardware shops, sometimes called "spring steelyards," of which, as I have said in my answers in the course of this croes-examination, I used a considerable number upon locomotives at that time. Such spring balances or scales couldn't possibly be applied as direct springs acting upon valves from above; but Mr. Richardson was free to use such as he now uses, because such use was a common right. No man could hope to evade Mr. Richardson's patent by substituting a weight for a spring while retaining the whole of his patented device.

Cross-int. 93. Do you mean by all that that you do not find any special directions as inquired of, or that you do find any special directions as inquired of, and which?

Ans. I find general directions which include all the special directions I require.

Cross-int. 94. And you have pointed out all the special directions there are?

Ans. I believe so; I haven't said that there were special directions; general directions, which include such special directions.

Cross-int. 95. Have you pointed out all the general and special directions that there are?

Ans. I think not. I presume the most succinct way would be to submit the patent itself, which is already in the case. Some other general directions I may quote. In speaking of the forms shown in this figure 1, he says: "The short case or hollow cylinder *g* may be dispensed with, and the sliding collar or flange *e* may be brought down on the stem *e* and *c* so as to rest on the top of the valve A." This would be substantially identical with the arrangements shown in Mr. Richardson's patent of 1866, except possibly as to proportions, if it can be properly be said that there are any proportions at all in Mr. Webster's patent, since he claimed, and was
280 entitled to claim, all possible proportions, being the first inventor in this field, and his patent being a foundation patent as relates to adjustable safety valves. I find another direction for making his valve in the manner shown in his figure 5; "that is to say, I make the sliding collar *o* in the form of a piston, fixed on the valve stem *t* as a piston-rod, and surround the said collar or piston *o* and valve-seat *q* with a hollow cylinder *r*, in which the piston or collar *o* works loosely; the said hollow cylinder *r* is perforated with a series of holes, *s s*. When the valve *t* has been raised by a pressure of steam, the said steam, acting on the under side of the sliding piston or flange *o*, raises the said piston or flange until it no longer covers or only partially covers the holes *s s*, when the steam freely escapes by said holes *s s*." And he describes another form, which, not to take up the record unnecessarily, I will not quote, unless required to do so; and then, as I have said, disclaims all details, but claims, very properly, as a first inventor, the invention of the sliding, adjustable flange or collar.

Cross-int. 96. In the Hartley patent the method of loading the valve described in the patent is as follows, is it not: "With regard to Fig. 8, the rod *e* is extended into the interior of the boiler, and a weight attached thereto, to agree with the pressure of the steam acting on the valve as required; and with regard to Fig. 9, the rod *e* is weighted as before mentioned." Is there another word in the said patent descriptive of the loading of the safety valves in that whole patent; and, if so, what is it?

Ans. No claim is made in the patent with regard to loading the safety valve. Such a claim would have been an absurdity. With regard to this whole subject of weighting safety valves, I adopt as my own the succinct statement of Mr. Charles W. Forbes, an expert called by the complainants in this case, as it appears on page 2 of the record, and add, if I may be permitted without presumption to say so, whatever weight my testimony may have to the testimony of Mr. Forbes. In speaking with regard to the common or ordinary safety valve shown in plate I of the record, he says, "Such valves have been loaded in various ways, to maintain them in their seats, and permit them to open whenever the pressure in the boiler
281 exceeded the load laid upon them, by a weight pressing directly upon them, by a spring acting directly upon them, and loaded either over or under them, when by such devices arranged in proximity to them and operating through intervening levers." In showing one of these several forms, or rather, I should say, in indicating it by a rod extending downward, and describing the rod as weighted, Mr. Hartley kept entirely within the common right, committed no impropriety in the exercise of his discretion. His patented device is another matter, and provides a method of lifting the valve and holding it up to effect a full discharge of steam.

Cross-int. 97. That is, I am to understand from your last answer that the quotations made in it are from the Hartley patent, am I?

Ans. I believe so, if there are any quotations.

Cross-int. 98. Mr. Forbes' deposition, then, you consider to be the Hartley patent, do you?

Ans. Oh, of course I don't mean to include any quotation expressly made from Mr. Forbes' deposition among quotations from the Hartley patent, if there are any such.

Cross-int. 99. The question put to you was, "In the Hartley patent, the method of loading the valve described in the patent is as follows: 'With regard to Fig. 8, the rod *e* is extended into the interior of the boiler, and a weight attached thereto, to agree with the pressure of the steam acting on the valve as required; and with regard to Fig. 9, the rod *e* is weighted as before mentioned.' Is there another word in the said patent descriptive of the loading of the safety valves in that whole patent; if so, what is it?" Please tell me where in that question you obtained the liberty of quoting the Forbes deposition.

Ans. Certainly, with pleasure; because I was asked a question with regard to the rod extending into the boiler, as though it had something to do with Mr. Hartley's patent, to which I replied that

it had nothing in the world to do with Mr. Hartley's patent, except that he chose to adopt that one of the many common modes of weighting; and instead of stating that on my unfortified testimony, I chose to adopt the testimony of Mr. Forbes in this case, and add to it my own confirmation.

282 Cross-int. 100. Do you consider yourself entitled to argue this case to me, or do you consider yourself obliged to answer my questions?

Ans. I consider myself obliged to answer your questions, and to use no argument unless the question calls for an inference or an opinion; then, I suppose, I have a right to give a reason for my opinion.

Cross-int. 101. I asked you whether, as matter of fact, the Hartley patent contained any other words relating to the weighting of the safety valves described in that patent, except the words "the rod *e* is extended into the interior of the boiler, and a weight attached thereto, to agree with the pressure of the steam acting on the valve as required;" and also the words, "the rod *e* is weighted as before mentioned." And I further ask you, as matter of fact, to point out any further or other words in the Hartley patent that related to the weighting of the valves; to this you reply by a quotation from Mr. Forbes' testimony. Is a quotation from Mr. Forbes' testimony the best answer that you are able to give to that inquiry about a matter of fact; if it isn't, what is the best answer you can give?

Ans. I don't see any other language relating to incidental matter of weighting the valve, other than the incidental language quoted, which forms in no wise the subject of the patents, as far as I can see.

Cross-int. 102. Then your quotation from Mr. Forbes was intended to be irrelevant and irresponsive to my question, was it not; and if not, why not?

Ans. By no means.

Cross-int. 103. What was the strength of the spring you used with the Hartley valve?

Ans. Compression of spring for 100 pounds per square inch, thirteen-hundredths of an inch.

Cross-int. 104. What was the strength of spring that you used with your so-called Waterman valve?

Ans. Compression of spring for 100 pounds, seven-hundredths of an inch, at one time. I believe I used two springs with that;

283 I also used part of the time a spring having a compression of one-tenth of an inch.

Cross-int. 105. Will you explain why, in the valve which you call the Waterman valve, and the valve which you call the Webster valve, and the valve which you call the Hartley valve, you used the Kunkle case, and bored additional holes in it, in some cases on the top, in some cases on the top and sides, and in some cases more numerous on the top than in others?

Ans. A Kunkle case was used because Mr. Kunkle was the defendant in this case, and it was convenient for him to use his patterns

and his castings to embody the several devices inquired about; the holes were drilled to let off the escaping steam with all practicable freedom, so that it might escape substantially as though it were discharged into the open air, as in fact it was.

Cross-int. 106. Now providing the round holes in the exhibits you have produced as illustrating the Webster, Waterman, and the Hartley valve did not exist in the casing, would the steam escaping from the valve be impeded in its passage to the open air so as to interfere with the operation of the valve?

Ans. It would, probably. It is possible that the slits cast in the Kunkle case in the regular course of his manufacture might be sufficient. There may be more holes than are absolutely necessary. I think there are enough, and more than enough don't do any harm, since, if the steam is perfectly free, you can get no more than perfect freedom.

Cross-int. 107. Less than enough would vary the operation of the valve, would it not?

Ans. It would.

Cross-int. 108. It would vary it very materially if the escaping area was reduced one-half, wouldn't it?

Ans. I don't know that it would. I don't know but the slits cast in the cover would be sufficient, but I wanted to put it beyond doubt.

Cross-int. 109. It would vary it pretty materially if the escaping area, including the slits, were reduced .99, would it not?

Ans. If reduced so as to cause relative compression inside
284 of the case, respectively to the atmosphere, it would vary the operation; and I presume such a reduction as is described in the question would do that.

Cross-int. 110. Then relative compression inside of the case would retard the escape of steam, would it or wouldn't it?

Ans. I think it would.

Cross-int. 111. Relative compression inside of the case means, as I understand it, a compression greater than would be due to the resistance to the escape of steam into the open air without impediment; am I right?

Ans. It does; you are quite right.

Cross-int. 112. Now, taking the thing which you call the Waterman valve, which has holes on the side of the casing as well as on top, and the thing which you call the Webster valve, which has holes on the top of the casing, and the thing which you call the Hartley valve, which has holes on the top of the casing, was there any particular reason for making the holes more numerons and presenting a larger area in the Hartley valve than in the Webster, or for putting holes on the side in the Waterman valve than in the other two; and, if so, what was the reason?

Ans. In the Waterman valve steam is delivered, to a great extent, laterally from under the valve, and the holes in the side of the case seem desirable to give free exit to the steam.

In the Webster valve and in the Hartley valve the steam is guided upward by a ring around the valve, so that little steam, if any,

would escape by holes in the side of the case, if there were such holes. As to the relative freedom of escape of the steam from the Webster and Hartley valves, I find in each the same number of slits, namely, six, and the same number of holes, namely, twelve; all in the top of the case. There is little difference in the size of the valves, but not a very great difference; and I think the escape is absolutely free in all of them; and that was the only point aimed at; and that was necessary, because in the original devices all were provided with free outlet for the steam to the air. By the valves which are spoken of in the question as "the thing which you call the Webster valve," "the thing which you call the Hartley valve," and
285 "the thing which you call the Waterman valve," I suppose you mean exhibits in this case, marked, respectively, "Defendant's Exhibit Webster Valve," Fig. 3, "Defendant's Exhibit Waterman Valve," "Defendant's Exhibit Hartley Valve," and have answered accordingly. I aimed to make the delivery of steam as free in these copies of the several valves as it is in the original valves themselves—that is to say, absolutely free—and believe that it is substantially so.

Direct examination resumed:

Int. 113. Referring to cross-interrogatory 60, quoting from page 169 of the record, will you please give the last paragraph of your answer to cross-interrogatory 97 of your deposition in the Crosby record?

Ans. Certainly; it is as follows: "I mean by all that, putting the Webster drawing on all fours, and taking his diagram for working drawings in violation of all precedent, his valve would even then be a practical safety valve, capable of acting in the manner indicated in the question."

Int. 114. Had you, prior to the 17th of May, 1880, carefully examined the Richardson patent of 1866?

Ans. I had.

Int. 115. In answer to cross-interrogatory 26 of this examination, you stated that in 1868, when you first examined the pop valve as in that answer stated, you didn't inquire as to whether the valve would close within a few pounds of the desired working pressure of steam in the boiler; was any statement then made to you when that valve was explained to you, namely, in 1868, or for several years thereafter, as to avoiding by this device the reduction of pressure in the boiler below the working pressure?

Ans. There was no such statement to me, nor did I ever hear the question raised until it came up in the progress of the suit of the Consolidated Safety Valve Company against the Crosby Steam Gage & Valve Company.

JOHN C. HOADLEY.

286 Taken pursuant to the sixty-seventh rule of the Supreme Court of the United States, in equity, as amended, before me,

CHARLES LINTHICUM,
Notary Public.

CHICAGO, *January* 5, 1882.

Present: Mr. Thos. Wm. Clarke, of counsel for complainant; Mr. J. H. Raymond, of counsel for defendant.

Deposition of John C. Hoadley Resumed.

Direct examination by Mr. J. H. RAYMOND, of counsel for defendant:

Int. 116. Have you, since you last testified in this case, made experiments with safety valves which have already been introduced as exhibits in this case, or to be so introduced; and, if so, with what safety valves have you experimented?

Ans. I have made numerous experiments with the safety valve "Defendant's Exhibit Webster Fig. 3," and also many experiments with "Complainant's Exhibit Webster Fig. 1 and Fig. 3," but only with the valve belonging to said exhibit marked Fig. 3, and purporting to be made according to Fig. 3 of James Webster's patent drawings.

1. "Defendant's Exhibit Webster Fig. 3:"

This exhibit had already been used in numerous experiments already described in detail in my deposition in this case. It is extremely delicate, having been closely copied from said patent drawing, which, if the matter of strength or durability was thought of at all, must have been drawn with reference to some very low pressure, like 10 or 20 pounds per square inch. Most likely these matters were not thought of, as they did not enter in any way into the invention for which a patent was asked and granted.

Light and delicate as it was originally drawn, it was still
287 further reduced by cutting off the upper end of the hub of the flange, to put it into a Kunkle case, so that the small set-screw, by means of which the flange may be adjusted on the slender valve-stem, actually cut through the metal at the top of the hub. Still, it had borne so well the experiments I had already made that I thought it might endure those I desired to make. These would be more severe, as I desired to adjust the flange deeper in the ring, necessitating a greater lift of the valve and a more forcible compression of the spring. In fact the original set-screw gave out, and I had to have two new ones inserted—one at each side of the old one. These held the flange, and I completed my experiments; but the weakened hub became stretched or spread apart, so as to be very loose on the valve-stem, and the stem itself became indented by the points of the set-screws and slightly bent, so that the flange when screwed fast was no longer true on the stem, or at right angles with it.

On this account, and because I am unwilling to submit the exhibit in such an injured condition for examination and trial by complainant's counsel and experts, I have had a new valve and a new flange made just as these were when I began my experiments on them, except that the hub is a very little larger in diameter, and otherwise slightly strengthened. This new valve and flange are now introduced, and marked as an exhibit in this case "Defendant's Exhibit Webster Fig. 3 A."

I have also had a second flange made, a little stronger still, also now submitted as an exhibit in this case, and marked "Defendant's Exhibit Webster Fig. 3 B."

The flange B and the one with A are alike in every essential respect; both are equally conformable to Webster's drawing Fig. 3, and may be used interchangeably with each other, and with the original flange. I have made no experiments with either A or B. They are in the same condition in which the original valve and flange were when I began with them.

Wishing to continue my experiments with this interesting Webster valve, I also had made another valve and another flange like the original in all essential respects, but having the adjustment of the flange upon the valve-stem effected by a screw, and its
288 fastening in any desired position by a jam-nut. The screw has 25 threads to one inch. One-fourth of a turn then gives the flange a motion, up or down, of .01 inch.

The flat surface of the top of the flange is divided into four equal parts, and each of these fourth parts is subdivided into ten divisions, which therefore correspond to .001 inch.

By means of the wooden gauge submitted and marked as an exhibit in this case, "Defendant's Exhibit Webster Fig. 3 C," the flange can be set readily and accurately to any desired height—to .0005 inch, or even closer.

This valve, with its flange and jam-nut, is herewith submitted, marked "Defendant's Exhibit Webster Fig. 3 D."

I also submit a brass gauge composed of two wedges, which I used in setting the original flange at any desired height above the valve, marked "Defendant's Exhibit Webster Fig. 3 E."

With this valve and flange D in the seat and case of "Defendant's Exhibit Webster Fig. 3," and with the spring therein, I made 61 distinct experiments, comprising 224 separate observations of the time and pressure at opening and closing.

In 7 cases one observation constituted an experiment; in 12 cases, there were two observations; in 15 cases, three; in 5 cases, four; in 14 cases, five; in 4 cases, six; in 1 case, seven; and in 3 cases, nine observations for one experiment, All observations included in one experiment were nearly alike, conditions all remaining unchanged. The first opening in each experiment showed a little higher pressure than subsequent openings in the same experiment, probably on account of the lower temperature and greater stiffness of the spring at first; generally about one pound higher, occasionally two pounds. The least reduction which I found (except in a single observation, which gave one pound), with prompt, decisive opening and closing, was 2.7 pounds from 100; *i. e.*, opening at 100, and closing at 97.3 pounds. With the bottom of the lip on flange just at the level of the top of ring when the valve was seated, the reduction was 5.5 pounds from 100.

While the valve was discharging steam in this position of the flange, the opening between the valve and its seat vertically
289 was .06 inch, and the height from the top of ring vertically to the bottom of the lip on flange was also .06 inch. The

diameter of the middle of the passage between the flange and ring is 2.32 inches. The diameter of the steam-way, inside of ground-joint, is 1.13 inches; that of the valve, outside of ground-joint, 1.45 inches. The circumference of the outer opening, between the ring and flange, is therefore 1.6 times that of the valve-head, and 2 times that of the steam-way, and the cylindrical openings are in the same proportion, to say nothing of the horizontal open area between the ring and flange. While the valve is open discharging steam, the external orifice is nearly three times as great as the opening at the open valve, so that there is no stricture. With different adjustments of the flange these proportions vary, but the fact always remains that there can rarely be any stricture. The full detail of all these experiments would incumber the record to little purpose. It may suffice to give an example and a synopsis of results.

TABLE I.

Example: Experiment No. 61.

	Times noted.		Interval between.		Pressure noted.		Reduc'n of pres.	
Obs.	Opening.	Closing.	Opening and closing.	Closing and opening.	At pening.	At closing.	Actu'l	Per cent.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.				
1	4 14 5	4 15 12	0 1 7		100¼	96½	4	3.99
2	4 15 50	4 16 38	0 0 48	0 0 38	99	96⅝	2⅜	2.15
3	4 17 10	4 17 50	0 0 40	0 0 32	99¼	97	2¼	2.27
4	4 18 20	4 19 3	0 0 43	0 0 30	99¼	97	2¼	2.27
5	4 19 35	4 21 10	0 1 35	0 0 32	99	96¾	2¼	2.52
6	4 22 18	4 23 29	0 1 11	0 1 8	99¼	96¾	3¼	3 27
	Means.		0 1 1	0 0 40	99.38	96.65	2.73	2.74

In this example six openings or "pops" took place, followed by six closings, all clear and distinct, between 4 h. 14 m. 5s. and 4 h. 23 m. 29 s. p. m., an interval of 9 m. and 24 s.; the mean interval between opening and closing was 1 m. 1 s.; the mean duration of closure was 40 s.; the mean lifting or opening pressure was
290 99.38 lbs.; the mean closing pressure was 96.65 lbs., and the mean reduction of pressure was 2.73 lbs. per square inch, equal to 2.74 per cent. of the opening pressure.

I now give in a condensed form in the subjoined table all the experiments which I have made with "Defendant's Exhibit Webster Fig. 3 D," arranged in such order as, beginning at the lowest position at which the flange was set on the valve stem, shall proceed by successive adjustment gradually to the highest position at which I set it.

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TABLE II.

Experiments with "Defendant's Exhibit Webster Fig. 3," with Flange D.

No. of Ex.	No. of Observations.	Immersion of Flange.	Opening of Flange.	Interval between Opening and Closing.	Interval between Closing and Opening	Pressure noted At Opening	Pressure noted At Closing.	Reduction of Pres. Actual.	Reduction of Pres. Per Cent.
20	1	0.09		0.2.40		101.	49.5	51.5	51.
21	1	0.06		0.2.10		101.5	62.	39.5	38.9
22	1	0.05		0.3.14		100.5	67.	33.5	33.3
23	1	0.04		0.1.53		100.75	72.5	28.25	28.
24	1	0.03		0.2.5		100.	77.½	22.½	22.5
25	3	0.02		0.1.7	0.2.55	102.3	85.2	17.1	16.7
26	1	0.02		0.1.50		101.2	80.5	20.7	20.4
27	5	0.01		0.0.46	0.1.40	101.1	91.2	9.9	9.8
28	1	0.01		0.0.47		99.5	90.5	9.0	9.0
29	5	0.005		0.0.34	0.1.26	100.4	93.	7.4	7.4
30	2	0.005		0.1.2	0.2.25	99.6	86.5	13.1	13.2
31	5	0.004		0.0.33	0.1.12	100.6	93.8	6.8	6.8
32	5	0.003		0.0.38	0.1.1	101.	94.1	6.9	6.8
33	5	0.002		0.0.36	0.0.50	100.4	94.7	5.7	5.7
34	6	0.001		0.0.26	0.0.53	100.1	94.9	5.2	5.2
35	5	0.0005		0.0.24	0.0.51	100.3	95.0	5.3	5.3
36	5	0.0000		0.0.26	0.0.49	100.2	95.5	4.7	4.7
37	2	0.0000		0.0.23	0.1.15	99.3	94.8	4.5	4.5
38	2	0.0000		0.1.52	0.1.5	100.	92.3	7.7	7.7
39	9	0.0000		0.0.31	0.0.42	98.9	93.8	5.1	5.2
40	5		0.001	0.0.30	0.0.45	100.2	95.1	5.1	5.1
41	5		0.002	0.0.29	0.0.39	100.4	96.0	4.4	4.4
42	5		0.003	0.0.32	0.1.8	100.7	95.3	5.4	5.4
43	5		0.004	0.0.23	0.0.38	100.9	97.3	3.6	3.6
44	3		0.005	0.0.33	0.1.25	100.2	96.2	4.0	4.0
45	6		0.006	0.0.14	0.0.30	99.9	97.3	2.6	2.6
46	3		0.007	0.1.32	0.1.11	99.5	95.8	3.7	3.7
47	4		0.008	0.1.8	0.3.0	99.8	95.9	3.9	3.9
48	2		0.009	0.1.7	0.0.50	99.5	95.3	4.2	4.2
49	5		0.01	0.1.2	0.0.41	99.5	96.0	3.5	3.5
50	3		0.01	0.1.16	0.0.49	99.8	95.8	4.0	4.0
51	2		0.011	0.0.52	0.0.50	100.6	96.2	4.4	4.4
52	5		0.012	0.0.39	0.1.20	100.	96.3	3.7	3.7
53	3		0.013	0.0.38	0.1.5	101.2	95.9	5.3	5.3
54	3		0.014	0.0.40	0.2.3	100.8	95.8	5.0	5.0
55	3		0.015	0.0.41	0.2.4	101.1	96.1	5.0	4.9
56	2		0.02	0.0.46	0.1.7	100.7	96.	4.7	4.7
57	3		0.02	0.0.50	0.1.15	100.3	96.3	4.0	4.0
58	2		0.03	0.0.37	0.1.1	101.5	96.2	5.3	5.2
59	6		0.03	0.1.3	0.0.37	99.7	96.3	3.4	3.4
60	2		0.04	0.0.38	0.1.0	101.3	96.5	4.8	4.7
61	6		0.04	0.1.2	0.0.40	99.4	96.7	2.7	2.7
62	2		0.05	0.0.57		100.8	96.3	4.5	4.5
63	5		0.05	0.0.43	0.0.54	99.7	96.8	2.9	2.9
64	4		0.06	0.0.39	0.1.11	100.1	96.6	3.5	3.5
65	3		0.07	0.0.45	0.0.58	100.2	97.	3.2	3.2
66	2		0.08	0.0.53	0.1.50	100.5	96.5	4.0	4.0
67	9		0.08	0.1.0	0.0.43	99.7	96.7	3.0	3.0
68	3		0.09	0.0.27	0.1.1	100.3	96.8	3.5	3.5
69	4		0.1	0.0.38	0.0.30	100.8	97.3	3.5	3.5
70	4		0.11	0.0.45	0.0.50	100.4	96.9	3.5	3.5
71	3		0.12	0.0.53	0.0.47	99.9	96.8	3.1	3.1

TABLE II—Continued.

No. of Ex.	No. of Observations.	Immersion of Flange.	Opening of Flange.	Interval between		Pressure noted		Reduction of Pres.	
				Opening and Closing.	Closing and Opening	At Opening	At Closing.	Actual.	Per Cent.
72	2	.....	0.13	0.0.47	0.1.0	101.	96.3	4.7	4.7
73	3	.....	0.135	0.0.36	0.0.51	100.7	97.5	3.2	3.2
74	3	.....	0.14	0.0.44	0.0.40	100.3	97.2	3.1	3.1
75	2	.....	0.15	0.0.36	0.0.47	100.5	96.7	3.8	3.8
76	9	.....	0.15	0.1.41	0.0.39	99.9	96.8	3.1	3.1
77	3	.....	0.16	0.0.51	0.0.50	100.6	96.3	4.3	4.3
78	3	.....	0.16	0.1.8	0.0.48	100.7	96.5	4.2	4.2
79	4	.....	0.17	0.0.51	0.1.3	100.5	96.4	4.1	4.1
80	7	.....	0.25	0.0.59	0.1.5	99.6	95.6	4.0	4.0

(Here follows diagram, marked page 292.

293 & 294 In the foregoing table the left-hand column contains the serial number, designating the experiments, for reference. The second column gives the number of recorded observations comprised in each experiment. The third column shows the depth in decimal parts of an inch, to which the under side of the lip of flange was immersed below the top of the ring at each experiment, when the valve was seated.

The fourth column shows how much above the top of ring the under side of lip of flange was placed at each experiment, when the valve was seated. It will be observed that four experiments, comprising 18 observations, were made with the bottom of lip of flange, just level with the top of ring, viz., Nos. 36, 37, 38, and 39.

The fifth column gives the duration of the period of discharge between the "pop" and the closure of the valve.

The sixth column shows the interval of time between closing and opening. Of course these two periods depend on many things: the relative size of boiler and safety valve, the condition of the fire, feeding water into the boiler, drawing steam from it, and other circumstances.

The remaining columns are sufficiently explained by their headings.

This table is represented graphically as to the position of the flange (columns 3 and 4) and the corresponding reduction of pressure (column 10 at the right hand) on the diagram herewith submitted, marked by the lines E F G^1 G H and M N G O T, P Q R S, and T U V W, every figure in said tenth column being located on the scale at the margin of the diagram by a point in said lines. A glance at the diagram will show what a careful study of the table also reveals, namely, that there is nothing capricious, irregular, or disproportionate about the action of Mr. Webster's adjustable flange, but that the results to be expected from the statements contained in his patent follow upon every adjustment of said flange.

No. 547
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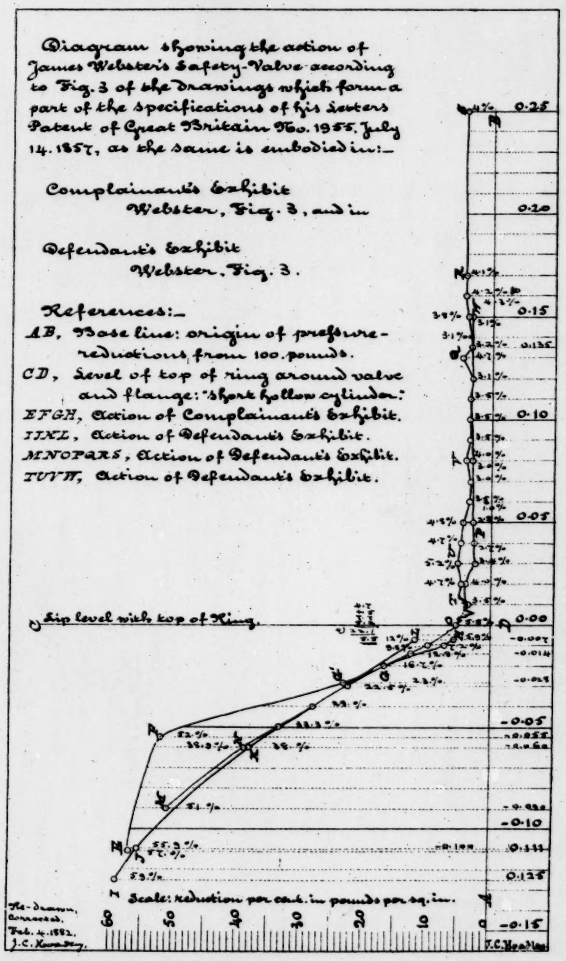
Diagram showing the action of James Webster's Safety-Valve according to Fig. 3 of the drawings which form a part of the Specifications of his Letters Patent of Great Britain No. 1955. July 14. 1857, as the same is embodied in:—

Complainant's Exhibit
Webster, Fig. 3, and in

Defendant's Exhibit
Webster. Fig. 3.

References:—
AB, Base line: origin of pressure-reductions from 100. pounds.
CD, Level of top of ring around valve and flange: "short hollow cylinder."
EFGH, Action of Complainant's Exhibit.
IJKL, Action of Defendant's Exhibit.
MNOPQRS, Action of Defendant's Exhibit.
TUVW, Action of Defendant's Exhibit.



When the lower edge of the lip of the flange is set below the top of the ring, a stricture is formed, so far as one feature of a stricture is concerned, namely, in that the opening of such stricture is
295 not enlarged by the lifting of the valve from its seat until the overlap is surmounted; but in these exhibits there can rarely be any true stricture as I have defined the word stricture (following Mr. Richardson's definition), on account of the considerable width of the supplemental area of the flange and the considerable width of the open space between the flange and the ring.

The deeper the flange is immersed in the ring the greater is the necessary lift of the valve. I found, by direct measurement, at the observation, experiment No. 82, subjoined, when the immersion was $\frac{1}{8}$ inch, and the reduction of pressure was from 100 lbs. to 41, equal to 59 per cent, marked I on diagram, that the valve, after the pressure had fallen to 60 pounds, was still raised from its seat .17 in., so that the overlap of $\frac{1}{8}$ in. was overcome and there was an open space, vertically, between the ring and flange of .045 in. The area of the cylindrical opening, .17 in. in height, 1.13 diameter, equal 3.55 in. circumference inside of steam way $= .17 \times 3.55 = .603$ sq. in. The cylindrical area of opening under the flange, above the ring, for a circle 2.27 in. diameter $= 7.13$ in. circumference, is $7.13 \times .045 = .321$ sq. in. But the horizontal open area is $7.29 \times .5 = .3645$ sq. in. Measured obliquely across from the upper inner corner of the ring to the lower outer corner of the flange, the width is $\sqrt{.05^2 + .045^2} = .062$ in., and the area of oblique opening forming a conical surface $= 7.29 \times .062 = .452$ sq. in.

This is still one-fourth smaller than the opening under the valve at inside of steam-way (.452 to .603 is only 75 per cent.), so that here is properly a stricture; the opening out of the annular chamber is smaller than the opening into it.

As soon as the flange is set a little above the ring, when the valve is seated, it at once lifts so far above it when the valve opens that there is little compression, and the escaping steam acts chiefly by force of impact, which diminishes but slowly, and would show no very marked diminution at the height of an inch or more. No diminution was apparent at the greatest height to which I carried it—.25 in.

I have also made some additional experiments with said exhibit "Defendant's Exhibit Webster, Fig. 3," using the valve and
296 flange originally made with it. These experiments were made — on the 17th of November, 1881.

Experiment No. 81.

I first tried it with the bottom of the lip on under side of flange set .06 in. above the top of the ring encircling valve and flange.

Pop at	100 lbs.
Close at	99 "
Reduction	1 lb.

The operation was good, as I had before found it to be in experiments heretofore given in this deposition.

Experiment No. 82.

I then set the flange so that its lip was .15 in. below the top of the ring; in other words, I gave .15 in. overlap. After two attempts, I found that the small set-screw, in its enfeebled seat in the hub, could not be made to bear the severe strain necessary to compress the spring not less than .2 in., and at the second trial it gave out entirely. I then had two new set-screws put in, as the same now appear in the flange of said exhibit. I then set the flange to an overlap of $\frac{1}{8}$ in. = .125 in.

2 h. 40 m. 0 sec. pop at	100 lbs.
2 h. 45 m. 0 sec. close at	41.5 "
Reduction	58.5 lbs. = 58.5 per cent.
Time valve remained open	5 minutes.
2 h. 52 m. 30 sec. pop at	100 lbs.
2 h. 56 m. 54 sec. close at	41 "
Reduction	59 lbs. = 59 per cent.
Time between former closing and this opening	7 m. 30 sec.
Time valve remained open	4 m. 14 sec.
3 h. 4 m. 40 sec. pop at	100 lbs.
3 h. 9 m. 20 sec. close at	41 "
Reduction	59 lbs. = 59 per cent.
297 Time between former closing and this opening	7 m. 46 sec.
Time valve remained opened	4 m. 40 sec.
Mean reduction of pressure	58.8 per cent.
Mean duration of opening	4 m. 38 sec.
Mean duration of closure	7 m. 38 sec.

The close coincidence of these results led me in subsequent experiments, involving such great reductions of pressure, and such long intervals of time, to limit each experiment to one observation, as already mentioned.

Experiment No. 83.

I next set the flange so as to give an overlap of .11 in.

Pop at	102 lbs.
Close at	45 "
Reduction	57 " = 55.9 per cent.

Experiment No. 84.

I then set the flange so as to give an overlap of .06 in.

Pop at	104 lbs.
Close at	64.5 "
Reduction	39.5 " = 38 per cent.

Experiment No. 85.

I then set the flange so as to give an overlap of .01 in., and took two observations.

Pop at	104 lbs.	
Close at	91 "	
Reduction	13 "	= 12.5 per cent.
Pop at	103 "	
Close at	91 "	
Reduction	12 "	= 11.6 per cent.
Mean reduction		12 per cent.

298 The results of these five experiments are laid down on the diagram in the line I J K L, and agree substantially with those laid down in the line M N G^1 G O.

I have also made several experiments with the safety valve already introduced as an exhibit in this case, marked "Complainant's Exhibit Webster, Fig. 3." This exhibit seems to have been made with commendable fidelity, according to Fig. 3 of James Webster's patent drawings, which it professes to embody, in so far as all essential features of said Fig. 3 are concerned. A judicious alteration has been made in the mode of adjusting and securing the adjustable flange, by substituting for the small set screw shown by Webster a threaded valve stem with a corresponding female screw in the hub of the flange, and a set screw to keep the flange from turning on the stem. The pitch of this screw is 18 threads to 1 inch. One turn, therefore, is equal to $\frac{1}{18}$ in. = .055 in.; two turns to .111 in.; $\frac{1}{2}$ turn to .028 in.; $\frac{1}{4}$ turn to .014 in.; $\frac{1}{8}$ turn to .007 in.; $\frac{1}{16}$ turn to .0035 in.; and 64° 48′ to .01 in.

This exhibit is weighted by a spiral spring acting at the end of the long arm of a lever of the third order, the fulcrum being at the other end of the lever. The leverage is 8 to 1; that is, the end of the arm to which the spring is attached has 8 times as much motion as the point at which the safety-valve stem presses upward on the lever. This arrangement works fairly well; quite as well as should be expected; but the really distinctive features of Webster's invention would have been a little more clearly brought out if a mode of weighting susceptible of a little more delicacy of motion had been adopted. This is, however, open to no grave objection.

Experiment No. 86.

The lower side of the lip of flange being first set just level with the top of ring, the flange was turned 2 full turns downward, and its edge was therefore immersed .111 in., or the overlap was, say, .111 in. extension of spring = $2\frac{1}{4}$ in.

Pop at	104 lbs.	
Close at	45 "	
Reduction	59 "	= 57 per cent.

299 I had removed the narrow loose oval ring surrounding the

fixed ring, so that I could observe the valve by looking across under it while it was relieving the boiler, but could not measure the opening, on account of the volume and force of escaping steam. I estimated the height of the opening at the greatest discharge to be about $\frac{1}{8}$ in., or a little more. The discharge all around this large flange, 2.27 in. diameter, at least $\frac{1}{8}$ in. high, was very free, and reduced the pressure from 104 lbs. to 45 lbs. in 5 m. 30 sec.

Experiment No. 87.

I then turned the flange 1 turn higher, making the overlap .055 in.; extension of spring, as before, $2\frac{1}{4}$ in.

Pop at ..... 102 lbs.
Close at ..... 49 "
Reduction ..... 53 " = 52 per cent. in 5 m. 30 sec.

The rise of the end of the lever where the spring is attached, and the corresponding rise of the valve, and position of the flange relatively to the top of ring are given below:

Time.		Pressure.		Rise of lever.	Lift of valve.	Opening above ring.
H.	*M. S.*			*Inch.*	*Inch.*	*Inch.*
2	7 30	Pop at.....	102	1.31	.164	.109
2	11 0		78	.75	.094	.039
2	12 0		60	.56	.070	.015
2	13 30	Close at.....	49	.41	.055	.000

Observation of the valve by looking across under it confirmed these figures.

Experiment No. 88.

I then turned the flange $\frac{1}{2}$ turn higher, making the overlap .028 in.; extension of spring, as before, 2.25 in.

Pop at ..... $95\frac{1}{2}$ lbs.
Close at ..... $73\frac{1}{2}$ "
Reduction ..... 22 " = 23 per cent.

300 Greatest lift of end of lever .05 in.; greatest lift of valve .063 in.; greatest vertical open space between top of ring and bottom of flange .035 in.

Experiment No. 89.

I then turned the flange $\frac{1}{4}$ turn higher, making the overlap .014 in. Spring as before.

Pop at ..... 100 lbs.
Close at ..... $87\frac{1}{2}$ "
Reduction ..... $12\frac{1}{2}$ " = 12.5 per cent.

Again:

Pop at	97½ lbs.	
Close at	85 "	
Reduction	12½ "	= 12.6 per cent.
Mean reduction, say		12.6 per cent.

Greatest lift of lever end .438 in.; lift of valve .055 in.; open space above ring .041 in.

Experiment No. 90.

I then turned the flange one-eighth turn higher still, making the overlap .007 in. Spring as before.

Pop at	102 lbs.	
Close at	94 "	
Reduction	8 "	= 7.8 per cent.

Again:

Pop at	102 lbs.	
Close at	97 "	
Reduction	5 "	= 4.9 per cent.

Again:

Pop at	100 lbs.	
Close at	95 "	
Reduction	5 "	= 5 per cent.
Mean reduction		5.9 per cent.

301 Experiment No. 91.

Finally I turned the flange *down* almost $\frac{1}{16}$ turn, so as to make the overlap .01 in.

Pop at	100 lbs.	
Close at	91½ "	
Reduction	8.5 "	= 8.5 per cent.

Again:

Pop at	100 lbs.	
Close at	91½ "	
Reduction	8.5 "	= 8.5 per cent.

Again.

Pop at	98 lbs.	
Close at	92 "	
Reduction	6 "	= 6.1 per cent.

Again.

Pop at	98 lbs.	
Close at	92 "	
Reduction	6 "	= 6.1 per cent.

Again:

Pop at	99 lbs.	
Close at	92 "	
Reduction	7 "	= 7.1 per cent.
Mean reduction, 5 observations		7.2 per cent.
Mean duration of opening, pop to close		2m. 30sec.
Mean interval between closing and opening		1m. 45sec.
Mean interval between pops		4m. 15sec.

302 TABLE III.

Recapitualation of Results of Experiments with "Complainant's Exhibit Webster Fig. 3."

No. of Experiment.	Overlap.	Reduction of Pressure.
86	0.111 in.	57 per cent.
87	0.055 "	52 per cent.
88	0.028 "	23 per cent.
89	0.014 "	12.8 per cent.
90	0.007 "	5.9 per cent.
91	0.010 "	7.2 per cent.

The results of these six experiments, comprising thirteen recorded observations, as given in the right-hand column of the above table, are indicated on the diagram already described by the line E F G^1 G H. Through all the practically more useful portion of the curve G^1 to H, indicating the operation of this valve when its flange is set so as to have, when the valve is seated, from .007 inch to .028 inch overlap, its operation is substantially identical with that of "Defendant's Exhibit Webster Fig. 3."

This portion of the curve includes four of the six experiments, and eleven of the thirteen observations.

Of the remaining two experiments, each consisting of a single observation, one, experiment No. 86 (marked E on diagram), conforms almost exactly to the other series of experiments with "Defendant's Exhibit." The other, experiment No. 87 (marked F on diagram), shows less exact conformity; but after careful consideration of all these experiments, I cannot find anything confirmatory of Mr. Charles W. Forbes' testimony, page 12 of record in this case, that "slight variations in the adjustment of the flange, up or down," produced "widely different and disproportionate results." Let us take the last four experiments in the foregoing recapitulation, Table III, arranging the last two in the order of the depth of overlap:

303 TABLE IV.

No. of Experiment.	Overlap.	Reduction of Pressure.	Differences.
88	0.028 in.	23.	
89	0.014 "	12.8	10.2
91	0.010 "	7.2	5.6
90	0.007 "	5.9	1.3

It will be seen at once that the sequence is unbroken and remark-

ably regular. The three last, 12.8 per cent., 7.2 per cent. and 5.9 per cent., reduction of pressure, are entirely "within the limits desired in practice," and the flange can be set so as to give any of these reductions, or any immediate reductions, with certainty and precision.

As a final result of all my numerous, careful and laborious experiments with these Webster safety-valves, I have ascertained:

1st. That "Complainant's Exhibit Webster Fig. 3," purporting to embody the invention set forth in Webster's letters patent of Great Britain No. 1955, July 14, 1857, does sufficiently embody said invention.

2d. That the application to said invention of the lever and spring was a needless embarrassment of its action, since, as Webster's successor, the public is just as free as Richardson was to adopt the simpler and better mode of applying force to hold a safety-valve in contact with its seat; namely, a direct-acting spring.

3d. That notwithstanding the inconveniance of the lever, "Complainant's Exhibit Webster Fig. 3" is a good, practical, useful safety-valve, and might be put to use judiciously upon any boiler of suitable size working under a pressure of about 100 pounds per square inch above atmospheric pressure.

4th. That said exhibit, just as it was when I experimented with it, would prevent an objectionable rise of pressure above that at which it should be set—not much exceeding 100 pounds per square inch—would promptly relieve a boiler of suitable size, say 15 to 18 horse-power, of all the steam it could be made to generate, and would close promptly at any desired reduction between 5.9 per cent. and 12.9 per cent., which are entirely within limits desired in practice; in proof of which I testify that I prefer to set the safety-
304 valves of portable steam engines manufactured for me under my patents so as to give a reduction of about 12 pounds at pressures ranging from 100 to 120 pounds.

5th. That "Defendant's Exhibit Webster, Fig. 3," is substantially identical with "Complainant's Exhibit," purporting to embody the same invention, so far as all the essential features of said invention are concerned, and is a better safety valve only in so far as it is a little better made, and in that it discards, as did Richardson, the lever and springs, and adopts, as Richardson also did, a direct-acting spring.

6th. That this exhibit, "Defendant's Exhibit Webster, Fig. 3," is a good, useful, practical safety valve, and would be a judicious safety valve to apply to any boiler of 15 to 18 horse-power at a pressure of about 100 pounds per square inch above atmospheric pressure.

7th. That Webster's patent, from the description, specifications, and drawings, of which two independent exhibits have been made, one with friendly skill, intent on obtaining useful results; the other with sufficient skill (presumably adverse), to demonstrate, if possible, that useful results could not be obtained by following said description, specifications, and drawings—which exhibits are in fact substantially alike in operation, and are both useful, practical

embodiments of the invention set forth in said patent, contains necessarily a clear, full, and accurate description of said invention.

Int. 117. You gave in a previous part of your deposition (p. 167 of record) an illustration of the effect of the different diameters of the steam-way and flange upon the relative openings at these points, with any given lift of valve, by comparing said openings with openings at certain points in a straight passage or conduit, with movable cover, said points being so chosen as to represent the circumference of the steam-way and the circumference of the lip of flange, or the stricture. Have you made a model to embody said illustration; and, if you have, will you please introduce it, to be marked as an exhibit in this case, and describe its operation?

Ans. I have made a very crude model for the purpose mentioned in the question, and now produce it, marked "Defendant's Exhibit, Hoadley, for Illustration."

305 One side, the one having paper pasted on it to mark on, is cut away so as to show the form of the passage between the bottom and the movable top. Holding the model erect with the papered side towards you, with one of the small wires in the hole marked *a*, at the left hand, passing through the hole in the valve at the outer end, and the right hand end of the valve pressed down upon the bottom of the passage, the point (near the middle) representing the ground-joint is seen to be closed; while the point (at the left hand) representing the stricture is open. If now the right hand end be raised, turning the valve on the wire at the left hand end, as on a hinge, the ground-joint is seen to open, while the opening at the stricture remains constant. This illustrates the action of an overlapping stricture until the overlap is surmounted. If we assume this to be the case when the right hand end of the cover (or valve) is so far raised that the other small wire can be passed through the hole in the valve at the position marked *c* (the upper hole at the right hand) and insert the wire, the passage will represent the openings at the ground joint and at the stricture just as the stricture is about to be enlarged by lifting above the top of the ring. If we now remove the wire at the stricture (the one at left hand), and raise this left-hand end upon the right hand wire as a hinge, which is placed at a point representing the centre of the steam-way, the relative enlargement of the opening at the ground-joint and at the stricture is seen by the space between the cover and bottom at the two points which represent the ground-joint and the stricture, respectively. Until the overlap is surmounted, the stricture is not enlarged while the ground-joint opens. After the stricture is surmounted, both openings go on increasing as the valve goes on rising; but the opening at the stricture increases most rapidly precisely in the proportion in which its radius exceeds the radius of the ground-joint as seen in the model.

Int. 118. Please examine the model now shown you, and state what it represents.

Ans. This model, marked "Defendant's Exhibit, Richardson Patent, 1886," represents George W. Richardson's safety valve according to his patent of 1866 upon a scale a little different from that of

306 the patent drawings, viz., about one-half linear dimensions. It is on a very little larger scale than the drawings of this same safety valve in the cut facing page 60 of the record in this case, as shown in figure 4 of said drawings. Taken in connection with the lever and spring balance, it correctly represents, as I believe, the safety valve described in Richardson's said patent. The upright wooden cylindrical casing in which the valve-seat is imbedded may be taken to represent the dome of a locomotive boiler, or some corresponding part connected with a boiler. The flat base is only a convenient object to which to attach the hook for the lower end of the spring balance.

(Defendant's solicitor offers the said model in evidence, marked "Defendant's Exhibit, Richardson Patent, 1866.")

Int. 119. Please examine the model now shown you, and state what it represents.

Ans. This exhibit correctly represents the invention described in Richardson's second patent, viz., of 1869, on a scale somewhat smaller than the scale of the patent drawings, viz., about one-half linear dimensions as the same are shown on a cut facing page 8 of the record in this case. This exhibit is also a little smaller in scale than the cut marked Figure 1 on the plate facing page 60 of the record in this case, but all parts are correctly represented in due proportion. This safety valve is shown as detached from and disconnected with any boiler. It might be bolted to an orifice in the boiler, or to a flange surrounding an orifice in the boiler or dome, by the flange surrounding the upper part of the valve-seat. This exhibit, I believe, truly respresents the invention of Mr. Richardson as most fully set forth in his said patent, which consists principally in the adjustable ring, by means of which a part of the escaping steam, more or less, after passing through the ground-joint may be diverted away from the stricture through another and a variable outlet.

(Defendant's solicitor offers the said valve in evidence, marked "Defendant's Exhibit, Richardson Patent, 1869.")

307 Cross-examination by Mr. THOS. WM. CLARKE, of counsel for complainant:

Cross-int. 120. I wish you would give me a little definition of the sense in which you used the word "patent" in this deposition of yours. Has it always been in the same sense and with the same signification?

Ans. I meant to distinctly refer to the United States patent granted to Mr. Richardson under the specified date. So far as I know, I have always used it in the same sense—letters patent of the United States, when referring to the United States patents—letters patent of Great Britain, when referring to British patents.

Cross-int. 121. When you use the word "patent," do you mean the document containing the grant, or the specification describing the thing sought to be patented, and containing the claims, or do you mean the thing claimed as a new invention?

Ans. I mean all these things with some limitation. It is sometimes true, as in the case of the second Richardson patent, that specifications contain a great deal of irrelevant matter—matter which was wholly stricken out of the claims or claims, and not stricken out of the specifications. In that case, I suppose I strictly mean by the word "patent" the document containing the claim or claims, and so much of the specifications as has any relevancy to the claim or claims allowed; and on careful consideration I suppose I take into view my knowledge of the state of the art by which the claims must be limited; but the most general answer would be, I mean the document which contains the description of the invention and by which it is secured to the inventor, properly construed and properly understood.

Cross-int. 122. Well, what do you call the document that describes the apparatus which the man tells about and illustrates by drawings—including the drawings, and taking in what you are pleased to term irrelevant matter as well what as you are pleased to consider relevant matter; what name do you give to that document filed by the inventor as a description to satisfy the law?

Ans. I should say, when filed, and before letters patent
308 were granted, that it was an application for letters patent; after the patent was granted, with or without more or less restriction, I should call such a document letters patent of the govment issuing it.

Cross-int. 123. On page 35 of the record is contained what is termed "Extract specification, in pursuance of the conditions of the letters patent filed by said William Hartley in the Great Seal Patent Office, on the 17th February, 1858;" was that the thing which, in your answers concerning the Hartley patent, you meant to be considered as the Hartley patent—that document?

Ans. To answer this question fully, I must say that, as I understand the English patent law, patents are granted at a certain date, upon condition that within a certain time thereafter full specifications of the invention claimed shall be filed. This specification, in pursuance of the conditions of the letters patent, seems to me, therefore, to be a part of the letters patent; or, at any rate, something by which the scope, meaning, and intent of the letters patent are to be ascertained.

Cross-int. 124. What else beside that did you refer to as forming a part of the Hartley patent in your testimony about it?

Ans. I think I referred particularly to the specifications filed in pursuance of the conditions of letters patent by the said William Hartley on the 17th February, 1858; but the provisional specification left by said William Hartley at the office with the Commissioner of Patents, with his petition, on the 19th August, 1857, is substantially the same, though a little less in detail.

Cross-int. 125. You then consider the provisional specification as part of the Hartley patent, do you, as you have used that term?

Ans. The petition was filed with the provisional specifications August 19, 1857, and the patent was dated 19th August, 1857. The provisional specifications and the complete specifications are identi-

cal in substance, and, so far as I understand the matter, are both parts of the patent.

Cross-int. 126. You have used the word in that sense, have you, as referring to the provisional as well as to the complete specifications?

309 Ans. Yes, I have no doubt I did, though I did not make the discrimination in my mind until now.

Cross-int. 127. When you talked about the Hartley patent, did you refer to anything else than those two documents—the provisional and the complete specifications; if so, to what?

Ans. I referred to the state of the art at the date of the patent as the same was known to me, and by way of illustration I think I quoted from the testimony of Mr. Forbes in this case.

Cross-int. 128. You consider, then, the state of the art at the time of the grant of the patent as a part of the patent, do you?

Ans. No, sir; but as showing something which could not be any part of the patent.

Cross-int. 129. Then, when you use the word patent, you do not confine yourself to the documents of the patent, do you?

Ans. Reading the patent with full knowledge that something which is referred to in it was well known and in common use, I should understand that such a reference to such a thing in the patent was only by way of illustration of the action of the patented mechanism and its connection with other correlated parts, and could not possibly be any part of the patented invention, especially if in any case such a thing was not mentioned and claimed.

Cross-int. 130. Will you give me a word or phrase that I can use in asking questions of you that shall indicate to your mind the document—the whole document, and nothing but the document—containing the description and drawings which the inventor files in England pursuant to the conditions of his letters patent, and which he files in America to be attached to his letters patent?

Ans. "Specifications and drawings," I should think, would be the best phrase, including in the phrase the claim or claims also.

Cross-int. 131. Will you look at the Webster patent drawing, Fig. 1, opposite page 390 of the record in the Crosby case, and say whether or not that does not represent exactly the Webster drawing, Fig. 1, contained in the English patent drawings of that Webster patent?

Ans. As nearly as I recollect, it does. I believe it does.

Cross-int. 132. Was there in either of the Webster drawings
310 any indication that the safety valve described by him and illustrated in his specifications and drawings was to be loaded in any other way than by the aid of a lever?

Ans. I do not think that it relates to the subject in any manner whatever, as the whole subject was long before entirely open to anybody to do as they pleased about it. An arm or lever is mentioned and indicated by the letter *d*. It is referred to incidentally in the following words: "Thereby counteracting the increased resistance which is offered to the raised valve, especially when said valve is pressed down by a spring." This, taken in connection with the reference to a lever, would plainly imply that the spring

might be attached to the end of a lever, as he had a right to attach it at that time. He, however, makes his whole device very general, having, so far as it was his device at all, a claim for a foundation patent in the following words: "I wish it to be understood that I do not limit myself to the precise details herein described and represented, as the same may be varied without departing from the nature of my invention." This must refer particularly to the details of his invention, but is applicable with even greater force to details which were not of his invention, which were the common property of all men in England and in the United States, and open to the use of Mr. Webster and everybody else at the date of his patent. Such a detail, not of his invention, but public property, is the mode of weighting a safety valve by springs above or below, with levers or without them.

Cross-int. 133. In the diagram which you have introduced, showing the graphic curve of reduction of pressure, what does the scale of 60 at the bottom of the diagram represent?

Ans. It represents pounds' pressure per square inch measured upwards from the base line A B, and is intended to show the number of pounds by which the pressure was reduced; or, more properly, the percentage of reduction from the opening to the closing of the valve, expressed in terms of the opening pressure by pounds per square inch.

Cross-int. 134. What do the large figures on the right of the line A B indicate?

311 Ans. They indicate, on a greatly enlarged scale, the position in vertical measurement of the bottom of the lip of the adjustable flange, referred to the top of the ring which surrounds the valve, as a base line. This base line is represented by the line C D, marked "level of top of ring." The first figures above, viz., .05, represent five hundredths of an inch clearance from the ring on a greatly enlarged scale, and so on upward. The corresponding figures, .05, represent five hundredths of an inch immersion of the lip within the ring, and so on downward. The reason for choosing an enlarged scale is simply to separate the figures far enough so that they might be inserted in a legible manner.

Cross-int. 135. What you have called the ring in the diagram and in your last answer is what is called in the Webster specifications, and indicated in the Webster drawings attached to the specifications, "the case or hollow cylinder *i*," is it not?

Ans. It is.

Cross-int. 136. And in the drawing Fig. 3, forming a part of the specifications and drawings of the Webster patent, the immersion of the edge of the flange *h* below the edge of the case or hollow cylinder *i* is shown to be, I think you have stated, .08 or .09 of an inch, is it not?

Ans. It is represented to be so adjusted.

Cross-int 137. With that adjustment of a valve the loss of pressure was more than fifty per cent., was it not, in either of the forms of the Webster valve which you tried?

Ans. It would be about fifty per cent.; rather more, probably.

Cross-int. 138. And until you got the flange *h* out of the interior of the case or hollow cylinder *i* the reduction exceeded five per cent., did it not?

Ans. Yes; it was 5.5 per cent. when the lip was level with top of ring, the valve being seated.

Cross-int. 139. You did not try the "Complainant's Exhibit Webster Valve," with the flange out of the interior or hollow cylinder, *i*, did you, in any experiments which you have put into your diagram?

Ans I did not..

312 Cross-int. 140. The two curves, E F G H and M N O P Q R S, indicate the action of different exhibits, do they not?

Ans. They do.

Cross-int. 141. Which exhibit has its action indicated by the curve E F G H?

Ans. "Complainant's Exhibit."

Cross-int. 142. Why have you put it down on your diagram as action of "Defendant's Exhibit?"

Ans. Because I made a mistake. I transposed the words. The line E F G H represents the action of "Complainant's Exhibit," and the line I J K L represents the action of "Defendant's Exhibit." I have now gone over all the figures and compared them and they are all right, except that I have transposed those words. I will make a corrected diagram of this.

Cross-int. 143. Then E F G H is the curve of action of the "Complainant's Exhibit?"

Ans. It is.

Cross-int. 144. And I J K L is the curve of action of "Defendant's Exhibit," is it?

Ans. It is.

Cross-int. 145. And M N O P Q R S is the curve of action of what exhibit?

Ans. Of "Defendant's Exhibit," with the new valve and flange which I have introduced as an exhibit, having a screw and set-nut for setting the flange, marked "Defendant's Exhibit Webster, Fig. 3 D."

Cross-int. 146. And T U V W represents the action of what exhibit?

Ans. The lines O P Q R S and T U V W, which are pretty nearly coincident, though a little separated, represent two series of experiments with the same valve, viz: "Defendant's Exhibit, Webster, Fig. 3 D." The figures in Table II are not all inserted in the diagram, simply because there is not room enough for them. In the space of a little over one-eighth of an inch between the line C D and the first dotted line above it there were nine experiments, which are recorded

313 in the table, and are indicated by the slightly zigzag line as correctly as the scale admits of indicating them. The line I J K L represents experiments with "Defendant's Exhibit, Webster, Fig. 3," and the original valve made with said exhibit

after the original set-screw had given out and two new set-screws were put in.

(Adjourned to 10 o'clock a. m. Friday, January 6, 1882.)

FRIDAY, *January* 6, 1882.

Cross-examination resumed:

Present: Counsel as before.

Cross-int. 147. You stated in your evidence in this case "I cannot find anything confirmatory of Mr. Charles W. Forbes' testimony, page 12 of record in this case, that slight variations in the adjustment of the flange up or down produced widely different and disproportionate results." Did you understand that Mr. Forbes made that remark with regard to the specific form of Webster's valve that you tried, viz: that shown in Fig. 3 of his drawings attached to his specifications? and, if so, please read the language of Mr. Forbes' deposition that brought you to that conclusion, and do not give me any other information on the subject but the paragraph of Mr. Forbes' language, on page 12, that produced that opinion.

Ans. I find on page 12 the following language, which brought me to this conclusion—the fifth, sixth, seventh, and eighth lines: "In my experiments with this valve, made in accordance with the Webster patent, I found that it could not be adjusted to operate within the limits desired in practice, nor to operate with a measured degree or reduction of pressure"—

(Witness interrupted.)

Cross-int. 148. That which you have read is one paragraph, is it not?

Ans. Yes, one paragraph, omitting (I will insert the whole if desired), but skipping over eight lines I find "slight variations in the adjustment of the flange up or down, producing widely different and disproportionate results."

Cross-int. 149. The entire paragraph from which you have read the words "slight variations in the adjustment of the flange
314 up or down, producing widely different results," is one single sentence, reading as follows: "With the valve set to open at one hundred pounds per square inch pressure in the boiler, and the flange adjusted upon the valve-spindle to leave a space (of one-eighteenth of an inch) between it and the top wall on the casing, as shown in Fig. 1 of the patent drawings, the valve partially closed when the pressure in the boiler was reduced to eighty-five pounds per square inch, showing a reduction of fifteen pounds per square inch, and at no other position of the valve could this margin of the reduction be obtained; slight variations in the adjustment of the flange, up or down, producing widely different and disproportionate results," is it not?

Ans. It is.

Cross-int. 150. From that paragraph, in which the only valve spoken of is the valve represented in Fig. 1 of the Webster drawings, you felt it to be fair, in speaking of experiments made with a valve

constructed according to Fig. 3 of the drawings, to say, "I cannot find anything confirmatory of Mr. Charles W. Forbes' testimony, page 12 of the record in this case, that "slight variations in the adjustment of the flange up or down, producing widely different and disproportionate results," did you?

Ans. I see that the experiment referred to was made, as he says, with a valve, as shown in Fig. 1 of the patent drawing. But in the first language which I cited he says: "In my experiments with this valve made in accordance with the Webster patent;" and there is no other safety valve mentioned in all that part of his deposition which we are now considering, except the Webster valve and the Green valve; and, therefore, when he says "this valve, made in accordance with the Webster patent," he must refer to the Webster patent, and not exclusively to Fig. 1 of the Webster patent, which no more exclusively contains the Webster invention than does Fig. 3 of said drawings. I did not notice, until my attention is now called to it, that Mr. Forbes nowhere says that he experimented with any Webster valve save one as shown in Fig. 1; but I did notice, as I now see to be true, that he spoke of such experiments as indica-
315 tive of the operation of Webster's patented invention. I tried the form shown in Fig. 3 because it afforded the widest range of adjustment, and because it seemed to me most likely to be useful, and because I believed I could show that Webster's patent did contain and describe clearly the means of efficient adjustment. At any rate, I believed I could find out whether it did or not. I do not know, and I would not intimate, that Mr. Forbes selected Fig. 1 exclusively for the opposite reason, because it afforded the least range of adjustment and was least likely to show useful results; but it is too obvious to require remark that "Complainant's Exhibit Webster" could have been introduced for no other reason but to show that it was not a practical, useful, safety valve. My experiments, on the contrary, with this exhibit, taking the form shown in Fig. 3, introduced by complainants, demonstrate that it is a practical, useful safety valve in this form; whether or not it be so in the other forms, I do not know by experiments.

Cross-int. 151. Do you mean by all that, that you think the quotation was fair or that you think the quotation was unfair?

Ans. I think the quotation was fair; for I believed, as I now believe, that the lines I omitted were excluded by the limitation of the question, and except for those limitations, as I understood them, I should have read the entire sentence.

Cross-int. 152. You think the quotation was fair, then, in the place where you first used it, do you?

Ans. I do. I quoted the paragraph with regard to the Webster valve. I quoted it fairly, as I believed. If I did not, what shall be said of the fairness of Mr. Forbes in condemning the entire Webster device upon his unsuccess with one form of that device? If any one form answered, that would be sufficient; if any one form failed, that would present no certainty that all the other forms would likewise fail.

Cross-int. 153. You have read the deposition of Mr. Forbes in the Crosby case, have you not?

Ans. I have.

Cross-int. 154. You are aware that in answer to interrogatory 30, on page 347 in that case, he described experiments made with both forms of the Webster valve, Fig. 1 and Fig. 3, are you not?

316 Ans. I have now read Mr. Forbes' answer to question 30 referred to, and distinctly remember that I had read it before. In his answer Mr. Forbes speaks of two experiments, each apparently of a single observation, one with an adjustable flange adjusted to the position in which it is shown to be adjusted in the above patent drawing, which is some .08 or .09 of an inch, I believe, lower than the top of the ring, and again with the flange lowered $\frac{1}{18}$ of an inch, which would be between .05 and .06 of an inch, making the whole immersion in the vicinity of .14 of an inch; and he says that in the first experiment, with an immersion of .08 or .09 of an inch in fact, pressure fell from one hundred pounds to forty pounds; and in the second experiment, with an immersion of about .14 of an inch in fact, the pressure fell from one hundred pounds to seventy-three pounds; a reduction in the first instance of sixty per cent., and in the second instance of twenty-seven per cent., or less than half as much. These results certainly are "irregular and disproportionate;" but my quite numerous experiments, embracing this whole range and much more, gave results strictly proportionate and not in conformity to those of Mr. Forbes; and that is all I said or intended to say.

Cross-int. 155. Do you mean by all that that Mr. Forbes did testify, in answer to interrogatory 30 on page 347 of the Crosby record, that he had made experiments with the form of Webster valve shown in Fig. 1, and with the form of Webster valve shown in Fig. 3, or that he did not testify that he had tried both of these forms? That was the question I put to you, and the only question that I put to you.

Ans. I mean that he did so testify as I said.

Cross-int. 156. The two observations to which you referred in your last answer but one were observations upon working of the valve represented in Fig. 3, were they not?

Ans. They were.

Cross-int. 157. Now in your diagram you represent the line E F G^1 G H as the action of "Complainant's Exhibit adjusted as shown in Fig. 3 of the Webster Drawings," do you not?

Ans. I do.

317 Cross-int. 158. The number of subdivisions of the scale on the right hand of that diagram, each representing an equivalent movement of the flange between E and F, are about four and a half subdivisions for a variation in reduction of 5 per cent., are they not?

Ans. Yes; that is so.

Cross-int. 158*a*. And the number of subdivisions between *f* and *g* on that scale of movement of the flange, are about two and a half for a difference in reduction of 29 per cent., are they not?

Ans. They are about two and a half. Each one of the dotted subdivisions represents one hundredth of an inch.

Cross-int. 159. Do you call a difference in reduction of 5 per cent. for a movement of four and a half degrees of the flange proportional to a difference of reduction of 29 per cent. for a movement of two and a half degrees of the flange?

Ans. There is a little irregularity in one of the observations, which I have clearly pointed out in my direct testimony, which I respectfully beg leave to refer to. Of six experiments, including thirteen observations, five experiments, comprising twelve of those thirteen observations, fall into a very regular curve, and substantially agree with all observations with the other exhibits. The remaining thirteenth observation, marked *f* on the diagram, showing 52 per cent. reduction at .05 inch immersion, is out of line. I gave it for what it is worth, and made the experiment fairly and recorded it accurately, to the best of my belief, but did not until long afterward group them together to see how they ranged, and there is certainly a slight irregularity in the line caused by that single observation.

Cross-int. 160. You do not then consider that difference wide or disproportionate, do you?

Ans. Not very. All physical experiments show some discrepancies. It is only by averaging a great number that absolutely satisfactory results can be obtained.

Cross-int. 161. Whereabouts, on your scale at the right hand of the diagram, would the line of Mr. Forbes' two experiments with regard to figure 3 in the Crosby record fall?

Ans. The first one, .08 or .09 of an inch immersion, would fall about the middle of the space above *m*, or at the line on which
318 *m* is locatad, or the first line above it, or somewhere between. That would be .08 or .09 immersion. The second experiment would fall near the upper end of the short lines in the scale at the bottom of the diagram.

Cross-int. 162. In making the adjustment of the flange on the Webster valve, with the smooth spindle and the flange attachment, with set-screws, by the aid of the contrivance "Defendant's Exhibit, 3 E," was it an affair of any length of time to make an exact adjustment of the height of the flange?

Ans. Yes, sir; it was troublesome; no very great exactness could be obtained without a good deal of trouble.

Cross-int. 163. Did you get your suggestion as to the construction of this ingenious "Defendant's Exhibit, Fig. 3 E," through the specifications and drawings of the Webster patent?

Ans. Not at all; no more than I did the multiplication table.

Cross-int. 164. This gauge was a piece of your ingenuity, was it not?

Ans. It was a device of my own to ascertain as nearly as possible just where the flange was set in any proposed experiment.

Cross-int. 165. In the experiments you made with the Webster valve, so-called, in the Crosby case, they were all adjusted by aid of a screw-thread on the valve-stem, were they not?

Ans. They were.

Cross-int. 166. As to the valve introduced by you yesterday, marked "Defendant's Exhibit, Richardson, 1866," can you tell me whether the spring on that valve is a strong spring, or a weak spring, or an ordinary spring?

Ans. I can tell by trying it. I have not tried it at all. (Trying same.) It is considered a weak spring. When set down to indicate 100 pounds it is quite as stiff as an ordinary spring; and in view of the size of the valve, one square inch area, or a little more, when set at 100 pounds, I should think it rather a strong spring. The leverage is about four and a half to one. The spring at the end of the lever is compressed about one and a half inch for 100 pounds, as it is marked. That would be about thirty-three one-hundredths of an inch compression at the valve. A corresponding spring
319 over the valve, therefore, would have one-third of an inch compression. Twenty-five one-hundredths compression over the valve is considered to be about an ordinary spring. By this rough computation it would be rather lighter than an ordinary spring. It is about an ordinary spring. Having continued my answer and my examination simultaneously, I give the final result as the best result I can come to.

Cross-int. 167. What is the distance separating the overhanging lip from the valve-seat in that valve?

Ans. Very small; about .01 of an inch; perhaps a little more.

Cross-int. 168. Do you not suppose that a difference between the diagrams E, F, G[1], G, H, and I, J, K, L, and M, N, O, are due in some degree to the fact that the stress of the spring, taken as over the valve, is in one instance equivalent to .1 inch compression for 100 pounds, and in the other about .28 of an inch compression for 100 pounds?

Ans. There may be some difference due to that cause; there probably is.

Cross-int. 169. Do you not also think that the level character of the diagrams O, P, Q. R, S, and T, U, V, W, particularly in the space above .05 clearance, is due to the fact that you used a very strong spring in the defendant's Webster valve?

Ans. No, I do not think that the level character is due to that.

Cross-int. 170. The adjustment during the space from .05 clearance to .15 clearance did not change the results particularly, did they?

Ans. Not particularly. The results were nearly constant—as nearly so as could be expected in any such physical experiments—because the cause was constant.

Cross-int. 171. But when the flange was adjusted up and down in the interior of the case or hollow of the cylinder *i*, a very slight adjustment of the flange produced considerable result, did it not?

Ans. It did.

Cross-int. 172. When did you go out of the portable-engine business?

320 Ans. I went out of all direct interest in the manufacture of portable engines in 1878.

Cross-int. 173. How long before that had you been using on your engines the pop safety valve?

Ans. A few months; four or five months.

Cross-int. 174. And how many did you use during the time you were engaged in the manufacture of portable engines?

Ans. I do not recollect exactly; something more than twelve, and possibly more than fifteen; I was doing very little in 1877. One order of ten engines had the pop safety valves; two other engines I recollect distinctly; how many more I don't remember.

Cross-int. 175. When you ordered your valves for your portable engines, did you give directions as to the reduction of pressure which you desired?

Ans. Yes, sir.

Cross-int. 176. Do you know whether or not that reduction of pressure which you ordered the valves to be set at was the ordinary reduction of pressure to which pop safety valves are set, or was it considerably more than they are usually set at?

Ans. It was considerably more than some people with whom I conversed thought best. I wanted them to lift at 132 pounds and to close at 120. This, however, was because I knew my boilers to be very strong, not in the least in danger by 132 pounds. I wanted, for economy's sake, 120 pounds for working pressure, and did not want to waste the heat between these two points. I will add that this is more than I consider proper for all boilers, but that no boiler should be used under any circumstances that will not bear with perfect safety and propriety five pounds more than the ordinary working pressure.

Cross-int. 177. Five pounds more than the ordinary working pressure would be a very small factor of safety, would it not?

Ans. I should not consider that a factor of safety at all. The factor of safety would be a multiplier, and would apply above the five-pound limit; and I should want the boiler to be from three to five times as strong as that. As to my factor of safety, whether
321 three or five, would depend upon the age of the boiler, its form, and other circumstances.

Cross-int. 178. You have made an illustration and comparison of a straight passage and a conduit with movable cover, and of a steam-way and flange; will you please tell me whether a straight passage under a movable cover, and a crooked passage or conduit under a movable cover, would work in the same way wiht regard to the pressure of steam upon the movable cover?

Ans. They would not work in the same way.

Cross-int. 179. If the angle in the crooked passage occurred after the steam had passed the cover, pressure on the cover would be greater than if the passage was straight after the steam had passed the cover, would it not?

Ans. It would; yes, sir.

Cross-int. 180. If the passage of steam into the atmosphere were impeded after the steam had passed the cover, the steam in the channel would be backed up under the cover and exercise a greater

pressure there than if the passage into the atmosphere were perfectly free, would it not?

Ans. It would. Change of direction produces resistance, and resistance increases the pressure behind.

Cross-int. 181. Will you cause to be marked the various valves which you referred to as experimenting with, and which you called "Kunkle Valve A No. 1," "Exhibit A No. 2," "Exhibit A No. 3," "Exhibit No. 4," "B No. 1," "No. 5," "No. 6," and which were not produced at the time of your examination in Boston, but have since been brought here, with tags showing which they are?

Ans. I have marked such exhibits so far as I find them here. "Exhibit A No. 1," "A No. 2," "No. 4," "No. 6," and "B No. 1." "Exhibits A No. 3" and "No. 5" I do not find among those now here.

Cross-int. 182. I understand you to use the word "stricture" to imply an opening between two cylindrical parts, one of them connected with the valve-head and the other with the valve-seat, and lapping past each other, which opening has a less area for the
322 escape of steam than there is at the valve-seats; am I correct in that statement?

Ans. Quite correct, with the addition, which may not be necessary, that such orifice is the outer orifice through which steam is discharged into the free atmosphere.

Cross int. 183. And in your judgment, as connected with the safety valve and as describing the necessary thing in the construction of the safety valve, nothing else is properly called a stricture; am I correct in that?

Ans. I think so; in connection especially with Mr. Richardson's valve. I adopted Mr. Richardson's definition, and it seems to me a correct one.

Cross-int. 184. Where did you get that definition from that you call Richardson's definition of the word "stricture"?

Ans. From the first portion of Mr. Richardson's specification of his patent of 1869, where he describes his previous patent of 1866, of which he says his subsequent invention is an improvement.

Cross-int. 185. I wish you would find me in either of the Richardson patents of 1869 the word "stricture."

Ans. Referring to my direct, page 154 of my record, I find that I have always examined Mr. Richardson's patent with the same object in view, and say, "Richardson accurately describes the 'stricture' as an essential part of his device without the use of the word 'stricture';" and then, as "a narrow space for the escape of steam, which, although of greater diameter than the valve-seat, presents a less area of opening for the escape of steam than is produced at the valve-seat." The word "stricture" is not used in that connection; so far as I recollect, is not used at all in the patent, but the thing itself is described; and not wishing to volunteer anything, and if it is not objected to, I would complete the quotation from the Richardson patent of 1869 which relates to that subject: "My said invention relates to improvements in the invention described in letters patent granted to me, and bearing date the twenty-fifth day of September,

1866, which said patent invented relates to a means for providing a more free escape for the steam than could be obtained by safety valves as constructed prior thereto, and when through the
323 keeping of the valve open until the pressure of the steam in the boiler or generator falls below the pressure which was required to open it; the said means so patented consisting of forming the valve with the surface outside of the ground joint for the escaping steam to act against, the said surface being surrounded by a projecting or overlapping lip, rim, or flange, leaving a narrow space for the escape of the steam when the valve is open, but which, although of greater diameter than the valve seat by reason of the said lap, presents a less area of opening for the escape of the steam than is produced at the valve seat, so that the steam which escapes from the area between the valve shall exert pressure against the said surrounding surface, and thereby open the valve completely and hold it up until the pressure of the steam in the boiler falls below the pressure by which the valve was opened."

Cross-int. 186. You do not then consider that the escape passage from the supplemental chamber to the atmosphere is what is technically known as a "stricture," unless that escape passage from the supplemental chamber outside of the valve seat to the atmosphere is of less capacity than the opening at the ground joint?

Ans. The question hardly admits of the short answer I should like to give, for the reason that when the valve is seated there is no opening at the ground joint, and then the stricture, unless also a ground joint, must at such times be more open for the escape of steam than the ground joint itself; but speaking of times when the valve is discharging steam freely through the ground joint into the intermediate chamber, and through the stricture from the intermediate chamber into the atmosphere, I should say I do consider the proportions I have described necessary to the stricture; that is, that the stricture be smaller in area than the opened ground joint or the opening at the ground joint.

Cross-int. 187. You are aware, are you not, that no other expert who has ever testified in any of the cases on the Richardson patent has given that restricted meaning to the word "stricture" which you give to it?

Ans. I am not aware that I have differed in that respect from Mr. Waters or Mr. Forbes. If I mistake not, Mr. Waters first
324 introduced the word "stricture;" at any rate, the word was adopted by Judge Shepley and Judge Clifford, and my recollection is that Mr. Waters treated it, if not in terms, yet impliedly, in the same manner that I do.

Cross-int. 188. The object of the stricture is to produce beneath the extended area of the valve-head a lifting pressure less than the pressure in the boiler, and greater than would be due to a free escape of steam from under this extended area, is it not?

Ans. That is so.

Cross-int. 189. And by enlarging the stricture this pressure is modified, but still continues to exist even after the stricture has become larger in area than the opening at the ground-joint, if the

expansion chamber between the ground-joint and the stricture be larger in cross-sections than the stricture, does it not?

Ans. By enlarging the stricture the action is modified, and the intermediate pressure is reduced, and gradually approaches nearer to the pressure of the atmosphere. With the ground-joint very wide open and discharging a very great volume of steam, some modified pressure would continue in the intermediate chamber of larger cross-section than the ground-joint, even if the opening of the stricture was somewhat larger than the opening of the ground-joint. At least, I believe so; I have never experimented on that point. I am giving this candid answer upon theoretical considerations. My reason for it is that a pressure in the intermediate chamber would be considerably less than in the boiler. The volume would be proportionately greater, and the escape of this greater volume through the open stricture into the atmosphere must cause some intermediate pressure, for a time at least, after the stricture has become larger than the opening through the ground-joint.

Cross-int. 190. You say you have never experimented on this. Did you not cause some valves to be made of a form modified from the Ritchie valve, as shown in his drawings, in which the opening into the atmosphere was larger than the opening through the ground-joint when the valve was open; and did you not characterize those valves so made as valves having "strictures"?

Ans. No; I think the opening under the ground-joint, when
325 the valve was freely discharging steam, was larger than the opening at the stricture. One of the essential qualities of the stricture—or one of the essential features of the construction—clearly pointed out by Mr. Richardson, is what is called the "overlap," on account of which the stricture is not sensibly enlarged until the overlap is surmounted, although the opening at the ground-joint goes on enlarging all the while, which causes an increasing quantity of steam to be discharged into the intermediate chamber, to be discharged ultimately through an outlet substantially constant in size; but as the steam must go out if it comes in, it must go out through the stricture faster and faster, which implies that the pressure behind it shall be greater and greater until the overlap is surmounted; then a certain rate of discharge is established and maintained, with gradual reduction, however, until entire relief is obtained, when the valve closes.

Cross-int. 191. Why did you say, with regard to the "Complainant's Exhibit Webster No. 3," that it was made with sufficient skill, "presumably adverse"; do you think that you were called upon to characterize, without evidence, the motive of the persons who caused that valve to be made?

Ans. It may have been an indiscreet remark. I do not lay any stress upon it, yet I suppose it would be admitted that said exhibit was not introduced for the purpose of demonstrating that Richardson's invention had been completely anticipated.

Cross-int. 192. Will you tell me in what part of the question in the answer to which those words occurred you felt yourself invited to characterize the motives of the manufacture of that valve? The

question is as follows: "Have you, since you last testified in this case, made experiments with safety valves which have already been introduced as exhibits in this case, or to be so introduced; and if so, with what safety valves have you experimented?"

Ans. In the words, "with what safety valves have you experimented." I designated the valves by their labels and by their characteristics; and I found in the adoption of the lever with a spring at the end of it, and a bearing of that lever on the stem, which caused considerable friction, the evidence of—I do not say un-
326 friendliness, but a disposition to adopt the less favorable adjuncts and appurtenances of Mr. Webster's device; and I think I spoke of that as an error of judgment. I certainly expected a little less freedom of operation from "Complainant's Exhibit" than from "Defendant's Exhibit," although they were absolutely identical in all that related to Mr. Webster's invention; and I found a little less freedom, but not so much less as I expected, and I said candidly that the "Complainant's Exhibit" was made with commendable fidelity.

Cross-int. 193. But you do not think it was "commendable fidelity" to use the lever which was illustrated in the Webster drawings instead of the direct acting spring which was not illustrated in the Webster drawing, do you?

Ans. I hardly think it was commendable to announce as Mr. Webster's device an irrelevant foreign matter, so to speak. Previous inventors had announced a choice of putting a spring above or a spring below directly upon the valve. He laid no claim to any combination with a lever above or below. It was no more part of the combination than was the grate under the boiler; and if the exhibit had been introduced with a distinctly friendly, instead of the presumably adverse, intention or animus, I think a more favorable method of loading among those in use by the public at that time might have been chosen.

Cross-int. 194. We have had your views on the subject of "commendable," now will you answer the other part of the question? You do not think, as I understand you, that it was "fidelity" to use the only thing which Webster showed in his drawings as a means of weighting his valve instead of the thing which he did not show in his drawings as a means of weighting his valves?

Ans. I do not think it a subject of any animadversion, or specially of commendation. I think, however, it shows some intimation of a presumable animus, that the arrangement that would result in most friction and less freedom of action was chosen.

Cross-int. 195. Is that the best view you have on the subject of fidelity?

Ans. Yes, sir; I think so. I might illustrate it in this way: Mr. Richardson, in his patent of 1866, describes a similar arrange-
327 ment of lever and spring as clearly as Webster does, or substantially so, although Webster shows a lever and Richardson does not; yet I am not aware that complainants have ever produced, nor do I believe they would feel themselves bound to produce, a model of the Richardson valve restricted to the use of a lever with

a spring at the end of it to elucidate his device in his patent of 1866. But I admit that in causing the model to be made which shows this arrangement, introduced here as an exhibit, I did intend to show a less complete and satisfactory arrangement than the one practically adopted by Richardson, and at all times open to his adoption.

Cross-int. 196. And when you used, to illustrate the devices shown in the Webster specifications and drawings, a direct acting spring which was not shown or described in the specifications or drawings, instead of the lever which was described in his specifications and drawings, you considered, as I understand you, that you showed greater fidelity to the Webster specifications and drawing than if you had used the thing which was illustrated in the drawing of that specification; am I correct?

Ans. Yes, sir; I think I did, for reasons which I do not wish to volunteer; but I think I did.

Cross-int. 197. Which valve does "Exhibit A1, A2, A3, B1, 4, 5, or 6," repreresent, as you understand it, the Kunkle valves complained of in this case?

Ans. Well, I believe A1 valve does, and A2 does not; I believe A3 does; I believe B1 does; about No. 4, No. 6, and No. 5, I am not so sure.

Cross-int. 198. And do you understand that valves like "Exhibit 4" are made and sold by Kunkle, and put upon the market?

Ans. Not in all respects. I believe the holes in the case containing the valves were made for the purpose of making these exhibits.

Cross-int. 199. And why were the holes made in the case of this exhibit?

Ans. To remove as far as possible all resistance to the escape of the steam after it leaves the opening below the flange around the valve and above the ring on valve seat.

328 Cross-int. 200. Did you try a valve of that sort without the holes in the vertical sides of the case?

Ans. I believe not.

Cross-int. 201. Would the use of continuous upright sides to the case instead of perforated sides, as in the exhibit, modify the action of the valve, other things remaining the same?

Ans. It would.

Cross-int. 202. And in order to make the valve work the same way that it does with the holes in the sides of the case, you would require to adjust the screw-ring in one direction or another, would you not, to get the same work?

Ans. Perhaps so. The effect of omitting the holes would be twofold. First, it would impede the flow of steam somewhat and produce a little greater upper pressure under the flange of the valve; and, second, it would increase the rapidity of the escaping jets out of the segmental openings in the top of the case, and so increase the suction on the top of the valve. That suction, if the holes in the top of the case for the insertion of a tube were plugged up, would show itself an important feature. As it is, with the holes in the case open, the principal auxiliary force to aid in lifting the valve—in fact almost the whole—is the force of impact of escaping

steam directly upon the flange around the valve, and the compression under the flange due to an abrupt change to the direction of the motion of the escaping steam; functionally, this is much the same thing as the relative compression due to Richardson's entirely different device—the stricture. The force of impact is pretty nearly constant at all practical variations of height. It would not be very sensibly dimmished if the valves were raised half an inch. The other portion of the pressure, namely, compression, is due to a change of the direction of the steam, and diminishes with increasing height. Referring directly to the question, I think some adjustment of the adjustable ring would be required to make the action with the holes in the case similar to what the action would be without the holes in the case.

Cross-int. 203. The accumulation of pressure underneath the flange is due to the retarding of the passage of steam beyond the flange towards the open air, is it not?

329 Ans. It is.

Cross-int. 204. The same is true with regard to the operation of each of the exhibits, A No. 1, A No. 3, No. 5 and No. 6, is it not?

Ans. It is substantially so.

Cross-int. 205. In the "Exhibit A No. 1" this retardation is in part at least affected by causing the steam to turn an abrupt corner greater than a right angle immediately under the flange, is it not?

Ans. It is.

Cross-int. 206. By what factors is the force of impact measured; are they not the weight of the molecules of steam which strike the flange, multiplied by the velocity with which they strike it?

Ans. The force of impact is as the weight of molecules of steam multiplied by the square of the velocity. Double the velocity would give four times the momentum.

Cross-int. 207. And you found that for some reason or other, in your experiments with "Exhibit A No. 1," did you not, that this was a negative quantity; or that the force of impact, plus the expansive force exerted on the valve head, was five pounds less than the expansive force exerted on the bottom of the chamber surrounding the valve-seat?

Ans. Yes, sir, I found such a state of facts. Not that the force of impact was a minus quantity.

Cross-int. 208. What other explanation is there of this extraordinary phenomenon?

Ans. I am not able to give any satisfactory explanation of it. The effect on my mind was to make me very careful to scrutinize the fact, to show that it was not an illusion or a mistake.

(Adjourned to Saturday, January 7, 1882.)

JANUARY 7, 1882.

Cross-examination resumed:

Cross-int. 209. How long has it been known, as far as you are aware, that a curvature in a steam passage would impede and

restrict the progress of steam through that passage to the open air, and to what extent, so far as you know, is the progress of steam impeded by a complete turn, or four right angles, or their equivalents?

330 Ans. It has been known from the earliest investigations of the subject. The earliest source of my knowledge on the subject is, I believe, "Rankine's Work on the Steam Engine," but it was by no means new. The laws of hydraulics have been carefully developed, and the fact that elastic fluids obey substantially the same laws has very long been known. The degree of obstruction afforded by turning four right angles I cannot answer as proposed in that bald way. Other conditions must be taken into the question, such as the size of the passage, the velocity of the current; if the circumstances were all given I think I could compute the obstruction, but I cannot answer the question off-hand.

Cross-int. 210. You may know very well when you first read Rankine's work, and you may know very well when you first studied the subject, but I apprehend that that knowledge is not the common property either of counsel for defendant or the court, and I am certain it is not mine; and therefore will you please answer how long you have known the thing inquired of in the last question?

Ans. Twenty years. And, now I think of I, I knew the fact that all turns in steam passages caused obstruction, and that that obstruction was approximately known and allowed for in arranging pipes for steam engines and for heating buildings certainly in 1848.

Cross-int. 211. Am I correct in assuming that your consideration of this case excludes the question of the character of weight or load that is applied to the safety valves concerned in the case; that is, that the question of the valve and its identity is to be determined without considering whether it is loaded by a weight or a spring, and whether it is loaded by a weight on the end of the lever or a spring on the end of the lever, or by a weight or a spring placed directly over or under the valve itself?

Ans. I think I may answer you yes, as I understand it; and, considering this case, the scope of Richardson's invention as defined by his claim and the corresponding specifications, and as limited by the state of the art at the date of his invention, I do exclude all consideration of springs and weights, except that I admit that Mr. Richardson proposes a sort of proportion between parts of his invention, namely, those parts which constitute the "stricture," as it

331 has since been called, and springs or balances, which he classifies as ordinary or strong or weak, so far I take springs into consideration and no further, except as my attention is called to them and I am asked questions about them.

Cross-int. 212. Am I right also in supposing that in your judgment the degree of compression of a spring for a given pressure, or of its extension when placed at the end of a lever is of no consequence in considering the nature and character of the mechanisms concerned in this case?

Ans. I consider them as of no consequence further than this: that a requisite amount of such knowledge would be the necessary

equipment of a man skilled in the art, to whom alone these patents are addressed, and who would be incompetent to construct safety valves according to the patents inquired of, unless he possessed the requisite amount of this knowledge of springs and their qualities.

Cross-int. 213. Will you tell me, then, how you are able to say that a man skilled in the art, as the art existed in 1858, would in the year 1858 have been enabled to apply a spring to the Webster valve which should give a degree of reduction amounting to three or five per cent. of the boiler pressure and no more, in any given valve constructed with "Chinese fidelity," according to the Webster specifications and drawings?

Ans. I am confident that I possessed sufficient skill in the manufacture of springs to have made and finished a specimen of the art of spring making as that belonging to "Complainant's Exhibit Webster" in 1848, and I know that my skill did not exceed that of most men of my age who had anything to do with designing and constructing machinery; and that spring I have found to answer the purpose very well, so that I cannot doubt that the skill was common as far back as 1848, sufficient to make springs of the quality inquired about in the question.

Cross-int. 214. I do not doubt that you had sufficient skill to make the required spring if you knew what was required. Will you tell me where and when and how you found out what spring was required in the Webster valve "made with Chinese fidelity" according to the drawing, and where and when and how you found
332 out, and from what source, that a workman skilled in the art of making safety valves—not of making springs merely—in the year 1848 could have known the same thing.

Ans. I first found out what springs were well adapted to Webster's safety valve, when I first made the attempt to find out, and that was in the progress of this case and a preceding case; but I am confident I brought to that investigation no peculiar skill which I did not possess twenty years ago. When I first attempted to make a spring safety valve with a spring directly over it—not a Webster valve to be sure—I succeeded perfectly, and I am confident that I could have succeeded just as perfectly ten years earlier. I borrowed nothing from anybody, but simply applied my general knowledge to the subject, and am therefore satisfied that if I had attempted more than twenty years ago to make a spring or springs adapted to Webster's safety valves, copied even with "Chinese fidelity" from Webster's drawings, I should have succeeded. I most certainly should not, however, without special reason for doing so, have copied Webster's drawings with anything like "Chinese fidelity." I should have followed his invention strictly, and embodied it, to the best of my judgment, to the circumstances of my case; and then I see no reason to doubt that my general knowledge of springs, which was certainly no greater than multitudes of men possessed, was sufficient to enable me to satisfy the requirements of the case.

Cross-int. 215. When you first attempted to make a Webster

valve you did not copy the drawing with "Chinese fidelity," did you?

Ans. I did not as to dimensions or proportions. I did, however, follow his drawing as to all that is described as Webster's invention; that is, I applied an adjustable flange upon the stem of his valve of such proportions as I thought would be most suitable, and of such dimensions as I thought the pressure of steam it was to work under would require, and I never should have made a valve from his plans with absolute fidelity as to those details, which he says he in no wise claims, but for the suggestion to me, before unheard of, that the dimensions and proportions of a patent drawing might be taken and transferred to a working drawing.

333 Cross-int. 216. I seem to have been unfortunate in the phrase which I thought I borrowed from you, "Chinese fidelity," and so I will quote another part of your testimony and see if I can get an answer which, in my judgment, confines itself to the question. When you made your first valves that you called Webster valves you did not put Mr. Webster's drawing "on all fours and take his diagram for working diagrams," did you?

Ans. I certainly did not. I should have no objection to the substitution of the word "Chinese" fidelity for the word I used, and only avoided the use of the word as a question of taste, the frequent repetition appearing unnecessary.

Cross-int. 217. Now, when did you learn that with a Webster drawing "on all fours and taking his diagram for a working drawing" of what the necessary degree of compression of the spring for a given pressure would be in a valve constructed from a Webster drawing on all fours with it, taking the diagram for working drawings?

Ans. I first learned as a fact what was suitable in the case when I tried the experiment, which was, I think, on the eleventh day of October, 1881. I had the choice of many springs. The one I first tried answered; whether the others might answer as well, or nearly as well, or better, I don't know, since any one which answered my purpose was just as good as any other. This knowledge so acquired corroborated the judgment I confidently expressed in my evidence in the Crosby case, which counsel for complainant has just referred to, when I said that even putting Webster's patent "on all four- and taking the patent drawings as working drawings, in violation of all precedent, I still believed that it could be made a useful, practical safety valve." I am not quoting this language, but repeat it from memory, and I believe that is the substance of what I said.

Cross-int. 218. And your knowledge in 1881 with regard to that proportion of spring and the degree of compression required by the Webster valve was precisely the same, neither more nor less, with regard to that particular thing than the knowledge that you had in 1858, was it?

334 Ans. It was more with regard to that particular isolated fact. That was knowledge of an actual experiment made and the result ascertained. That knowledge differed not at all in kind or degree from general knowledge of the same character

which I had in 1858, which would have enabled me to do then what I did in 1881, had I then attempted it.

Cross-int. 219. Will you explain then why you said in the year 1880, with regard to valves having the proportion of flange as the valve shown in "Defendant's Exhibit Webster Valve Fig. 3 and Fig. 3 D," "I should never have been crazy enough to make such valves," in answer to cross-interrogatory 88, page 165, Crosby record?

(Defendant's counsel objects to this and subsequent questions as incompetent and inadmissible, which may be predicated upon the testimony in the Crosby record, for the reason that the record in the Crosby case has been stipulated into this case for the purpose of reference in argument only, and does not constitute direct testimony for either of the parties to this controversy, and is not therefore a proper subject matter for cross-examination; and, further, for the reason that in the cross-examination to the first deposition of the witness taken in this case, the subject matter of this question was fully gone into.)

Ans. Certainly, with pleasure. Knowing that it was my right and duty as a mechanical engineer and designer of machinery to apply to Webster's device the best proportions which my knowledge would enable me to select, I said, in a very emphatic way, I should never have been crazy enough to choose anything other than the best proportions which my skill would enable me to select; and I may say now, that I should not have been crazy enough to take a patent drawing for a working drawing, either then or now; and, I think, with permission, the language which follows that quoted in the question fully explains my meaning; it is as follows: "The Webster drawings would have served my purpose equally well had they been made with all that portion outside of the interior of the steam way exactly as in the drawings, and the steam way itself one inch, two inches, or three, four, five, or six inches in diameter, or any diameter smaller than one inch, or greater than six inches or of any intermediate diameter, since proportion does not enter into them at all;"
335 so I said, properly enough, I would not have been crazy enough to confine myself to forms, dimensions, and proportions shown in a patent drawing for the purpose of illustrating safety valves to be used under various conditions, without paying regard to the conditions under which I indended my safety valve to work.

Cross-int. 220. I read you from the Richardson paten of 1869: "One part of my present invention relates to a means for regulating or adjusting the area of the aperture for the escape of steam after acting on the said surface outside of the valve seat, so that the valve may be set to close at any desired pressure below the pressure which will open it; and this part of my invention consists in making the aperture or apertures for the escape of steam, after it has acted on the said surface outside of a valve seat, adjustable." Will you please tell me whether the area of the aperture for the escape of steam from under the surface outside of the valve seat, after acting on a surface outside of the valve seat in the Kunkle valves containing

the screw-ring, is not regulated or adjusted by means of the screw-ring?

Ans. It is so adjusted.

Cross-int. 221. And if I understand you correctly, the only thing described, in your judgment, correctly and fully in the Richardson patent of 1869, is the adjustment of the area of the aperture between the outer periphery of the flange *n* of the cap-plate and the inner periphery of the projecting rim *q* in the Richardson patent of 1869?

Ans. No, sir; I think there is no means described in Richardson's patent of adjusting the aperture referred to except in a vauge and insufficient manner.

Cross-int. 222. Then the aperture, the adjustment of which is described, is the aperture between the upper edge of the ring *u* and the disk *f*?

Ans. It is.

Cross-int. 223. The means for adjusting the size of this aperture between the ring *u* and the disk *f* is the screwing up or down of the ring *u*, is it not?

Ans. Yes, sir; it is so.

Cross-int. 224. And a mechanical contrivance used for the purpose of adjusting this aperture is what is called in the Rich-
336 ardson patent the threaded ring *u*, that can be turned up or down to any desired elevation and there secured by a set-scew *v*, is it not?

Ans. It is.

Cross-int. 225. Is the mechanical contrivance used in the Kunkle patent for adjusting the size of the aperture, through which the steam escapes from under the extended surface of the valve into the interior of the case, a threaded ring?

Ans. A threaded ring is used in the Kunkle valve. The effect of moving it up or down is more than merely to diminish or increase the aperture. Its functional use in the Kunkle valve is something different, but the mechanical device is, described as it is in the question, the same—a threaded ring.

Cross-int. 226. Does that threaded ring regulate the size of the aperture for the escape of steam from under the extended surface of the valve head into the case?

Ans. Not materially in the Kunkle valve; and I am not sure that it does practically make any difference, except as it guides steam more or less directly upward, since it cannot be set high enough to produce a real contraction in the nature of a stricture in most forms of the Kunkle valve which I have tried. In one form, namely, B No. 1, setting it so high as to make a stricture was detrimental to its operation. It worked best with the outer orifice wide open under the combined influence of impact, pressure due to the change or direction, and suction due to the current of escaping steam.

Cross-int. 227. Then I understand you to say that the adjustment of the screw ring in the Kunkle valve upward does not materially contract the orifice for the escape of steam from under the extended surface, and that its adjustment downwards does not materially en-

large the orifice for the escaping steam from under the extended surface of the valve; do you mean this as a matter of fact?

Ans. Considered simply as an orifice it does materially increase and diminish it. Considered as to its effect upon the escaping steam, I do not think it has any material effect, since the orifice, at its narrowest, is so wide as not to offer any obstruction.

Cross-int. 228. Does the change in position from the ad-
337 justment of the ring in the Kunkle vavles which you have tried, having the ring, change the operation of the valve at all?

Ans. It does.

Cross-int. 229. You have stated that the screw ring upon the valve seat of the Richardson valve tried by you is no part of Richardson's invention; will you tell me where you saw it before you saw it on the Richardson valve, and when, as applied to the safety valve?

(Objected to, as incompetent, as immaterial, by counsel for defence.)

Ans. I should be glad to be referred to the passage quoted, that I may read it in its context. I do not remember.

Cross-int. 230. Can you tell me where you saw it, and when, before you saw it on the Richardson valve, as applied to a safety valve? If you cannot, please say so; and if you can, please say so without referring to any context.

Ans. I do not know that I ever saw it before I saw it on the Richardson valve; but when I first saw it on the Richardson valve being familiar with Mr. Richardson's patent of 1869, I did not recognize it, and I do not now recognize it, as anything in common with his device as shown in his said patent.

Cross-int. 231. Then what you mean when you say that that ring is no part of Richardson's invention is that, according to your best judgment, it is not part of Richardson's described invention, is it?

Ans. That is what I mean.

Cross-int. 232. You have also stated with regard to a valve having a screw ring around its head, that that screw ring is no part of Richardson's invention; do you mean the same thing when you say that concerning the screw ring around the valve head?

Ans. I mean the same; that it is not part of his invention described in his patent. I refer to the patent of 1869.

Cross-int. 233. You are aware, are you not, that Mr. Richardson has testified that the screw ring on the valve head was contrived and put in use before 1869 on his valve.

Ans. I don't remember the testimony.

Cross-int. 234. Is there any difference between the mechan-
338 ical means of a screw ring on the edge of the valve, a screw ring on the edge of a seat, or the screw ring around a cylindrical orifice, so far as it is an instrument for the regulation for the escape of steam through the orifice, more or less obstructed, by the adjustment of the screw ring up and down?

Objected to by counsel for defence as incompetent and imma-

terial, and as no part of the subject matter for this cross-examination.

Ans. There is a very great difference in the mechanical device in the several cases. A screw ring upon the head of the valve may regulate the breadth of the stricture; will certainly regulate the depth of the overlap. A ring around the valve-seat may also regulate the width of the stricture, and may certainly be made to regulate the depth of the overlap in both cases. All the steam that escapes through the ground-joint having to flow through the stricture, which may be modified in width, and must be modified as to the overlap; that is, as to the height to which the valve must be lifted before the material relief begins to be afforded at the stricture; but in the case of a ring, band, or subsidiary orifice above the valve B, communicating by openings with the intermediate chamber, by means of which more or less steam may be drawn away from the intermediate chamber and never reach the stricture at all, regulation is obtained by mechanical means entirely different; not at all similar to that of the other two cases I have described. In this latter case the orifice itself remains unchanged, the ovarlap unchanged, and more or less of the escaping steam is suffered to go through it simply because more or less is drawn off in another way. So distinct is this method of relief or regulation from the other two, that it seems to me to contain sufficient invention to sustain a patent by itself quite independent of any other method known to me.

Cross-int. 235. Then the screw-ring on the head of the valve, the screw-ring on the valve-seat, and the screw-ring around the cylindrical orifice, are not all of them, in your judgment, screw-rings, are they; and if not, which is not the screw-ring?

Ans. They are all screw-rings, most certainly.

Cross-int. 236. Is there any adjustable mechanical means other than the screw-ring used for regulating the size of the orifice
339 for the escape of steam in either of the three valves; and if so, what is that adjustable mechanical means?

Ans. There is no other adjustable mechanical means in either of the cases.

(Adjourned to Monday, January 9, 1882.)

JANUARY 9, 1882.

Direct examination resumed:

Int. 237. Referring to your cross-examinating upon the character and location of the springs, scales, or weights of the several devices introduced, what, if anything, did you find in the Ritchie patent upon this question?

Ans. I have not a certified copy of the Ritchie patent at hand, but I find a copy in the record of the Crosby case, in which, on page 71 of said record, I find the following language:

"This valve is weighted by the helical spring I (shown at Fig. 2), of sufficient power according to the required pressure of the steam; and when it is to be used as a reserve safety valve, I place the spring around that part of the stem below the valve; that is to say,

within the boiler, as shown at Fig. 2. When not intended as a reserve safety valve this valve may have the spring, I, placed above it."

Again, on page 75 of said record, among the claims I find—

"Fourthly, I claim the construction of the safety valve with the flange, termed the compensation flange, without regard to the manner in which such valves may be weighted, as hereinbefore particularly described and represented in Fig. 7 of the drawings hereto annexed."

Int. 238. In your direct examination, in the use of the word "patent," did you intend to give it any, and if any, what different signification as applied to the Webster patent on the one hand, and to the Richardson patent on the other?

Ans. Not at all. I attempted to make no discriminative use of the word, but supposed I was using it always in its most obvious and intelligible meaning.

Int. 239. I understood you to testify that there was irrelevant matter in the Richardson patent of 1869, from which I understood you to mean there was matter contained in that patent not relevant to the invention of Mr. Richardson described and explained therein, and that you used the word "patent," as applied to this specification and claim of the Richardson patent of 1869, as referring to the invention described and claimed therein. In referring to the Webster specifications, drawings, and claim, did you use the word "patent" in the same exact signification?

340

Ans. I did speak of the irrelevant matter in the Richardson patent of 1869, and I referred to that portion occupying about a page and a third, namely, about the last third of page 19 and the entire page 20, in the Crosby record, relating to a mode of forming a bearing for the valve-rod, stem, or pintle, low down in the valve below the valve-seat. This relates to matter concerning which there was a claim in the application, but the file-wrapper and correspondence show that the claim or claims relating to this matter were stricken out, while no corresponding expurgation was made in the specifications. I therefore had no reference to this matter in speaking of the Richardson patent of 1869. With regard to the Webster patent, I used the word in the same sense, in that I referred to everything contained in said patent having reference to an adjustable flange for regulating and lifting the valve, and everything bearing upon that subject; and I think I used the word "patent" in both connections as a distinct and specific reference to an authentic document, where these matters are to be found.

As there is, so far as I perceive, no irrelevant matter in the Webster patent, I think I must have referred, as to the Webster patent, to all it contains.

Int. 240. In answer to one of the cross-interrogatories, you stated that the adjustable ring in the Kunkle valve did not materially affect the escaping steam, and said you would give your reasons for that opinion, if requested so to do. I should be glad to have you do so.

Ans. My reason is, that when the adjustable ring is so set as to

produce the greatest diminution of the opening it is capable of producing, the opening is still so large, when the valve is raised sufficiently to discharge steam freely, that there is no real contraction, and no real obstruction of the flow, for the steam must flow
341 out wholly or almost wholly against the upper surface of the opening, little, if any, coming in contact with the lower surface or top of the adjustable ring.

One evidence, to my mind, of this state of facts is that I could never find any downward pressure at the upper surface of the adjustable ring. Another is that when the valve is opened in the manner I have described, with the ring at its highest position, the opening is larger at this point than through the ground-joint, and larger than through the intermediate chamber. Steam is therefore flowing out through a channel which is nowhere enlarged and then contracted, but through a channel which is enlarged from within outward. It is obstructed, it is true, by having twice to change its course, and these obstructions increase the pressure. Still the pressure is a diminishing pressure from within outward. There is no room for intermediate relative compression, and this, I think, though I speak modestly and diffidently on this subject—this, it seems to me, is the reason why the downward pressure just inside of the ground-joint at the surface level with the valve-seat is really greater than the upward pressure combined with the force of the impact on the under surface of the flange surrounding the head of the valve, viz., that the steam, flowing outward through a channel enlarged from within outward, goes on falling in pressure all the way, so that the hole nearer the edge of the ground-joint, being at a portion where there is greater pressure in the channel than at any portion nearer the exit, is actually subjected to a greater pressure.

I do not think that this is an entirely satisfactory explanation of a fact which I know to be true.

Now in all this which I have stated in answer to this question, my remarks must be taken as applying to all the Kunkle valves I have experimented with, excepting the large "Exhibit B, No. 1." In that valve the ring can be set high enough to come in contact or almost in contact with the flange around the valve without actually impeding the seating of the valve. In this case there is a stricture, and I found that with one spring—a spring not belonging to the valve, and one which I did not find in the similar valves of Mr. Kunkle's manufacture, namely, a very stiff spring—that under
342 certain circumstances this stricture could be made operative as a stricture; but that the same valve, and the spring which I found in the valves of Mr. Kunkle's manufacture, and which operated perfectly so long as the ring was set low enough to leave an open mouth as large as or larger than the channel between it and the boiler; but when I set the ring so high as to produce a stricture it interfered with the operation, and its performance was by no means satisfactory. This formation of a stricture in that case seems therefore to me to have been accidental, without intelligent or useful purpose; in fact, detrimental, and not an adjustment which

could be practically employed in the ordinary use of the Kunkle valve "B 1."

It could only be introduced experimentally as a *tour de force*, and is not characteristic of the Kunkle valve; but, as I have stated, nothing of the kind can be found in the other exhibits. Before the rings could be raised high enough to produce a stricture they were entirely unscrewed from their seats.

Int. 241. Did I understand you to testify that there was warning before the pop in the Kunkle valves?

Ans. No; generally there was none. Sometimes there is a scarcely sensible whispering sound before the pop, but generally the two events are so nearly simultaneous as not to be distinguished by the ear. This results, I think, necessarily from the immediate effect of the percussive force, or force of the impact in opening the valve, while in the Richardson valve and in some other valves there is a gradual increase of the pressure in the intermediate chamber, which only produces a pop after it has acquired sufficient energy. The Kunkle valve appears to act promptly by impact of the escaping steam.

Int. 242. Will you please state a little more distinctly what parts you refer to, and their relative size to each other, in speaking of the proportions, which you say are more or less definitely laid down in Richardson's patent of 1866.

Ans. All the proportions I find in said patent are described in the words to be found on pages 136 and 137 of the record in this case. The proportion between the supplementary area and the valve, "about the proportion shown; the overlap of the stricture," 343 as it has been called, "slightly below," the lip projecting "slightly below" the outer edge of the valve seat and "fitting loosely around it;" an annular chamber "of any desirable form or size;" the flange or lip separated from the valve seat by about one sixty-fourth inch for an ordinary spring; less for a strong spring, and more for a weak spring. These proportions, it is true, are extremely indefinite, and if this be a patent upon these proportions, then it follows that any other proportions not conformable to these cannot be included in its claim, for if they could, the absurd conclusion would follow that other proportions of these same things, which had long ago become common property, are also included in it, such as Ritchie's, Webster's, Naylor's, and Beyer's. The functions performed by the parts of the Richardson valves, proportioned as he directs, can be well performed, as I have demonstrated by experiments, by corresponding parts proportioned in a manner widely different—so different as to afford no comparison, but only contrast. In such contrasted proportions I cannot find any trace of Richardson's invention, as described and claimed by him in his said patent. For instance, I find in the Kunkle valve that there is no enlarged intermediate chamber, and no narrowed outlet from that chamber to the atmosphere; but, on the contrary, a trumpet-shaped opening from within outward, zig-zag, it is true, but still constantly enlarging. I find no trace of Mr. Richardson's annular chamber or contracted opening, and this overlap, which we understand as a stricture,

but wholly different mechanical devices. For weighting his valve he practically discards the method definitely referred to in his patent of 1866, and adopts, as he had a perfect right to do, another well-known device for weighting. I do not see that Mr. Kunkle, in availing himself of the same common right to the same form of weighting, infringed anything contained in Mr. Richardson's invention, as described and claimed by him in his said patent. Mr. Richardson refers to a certain vague and indefinite proportion between the width of his stricture and springs as ordinary, strong, or weak; but Kunkle has no stricture whatever, and, of course, no proportions between these parts.

Int. 243. In determining in 1858 what tension of the spring
344 you would use in any valve or valves, what elements would you have considered—I mean all the elements which in 1858 would have been considered by you at that time in determining what tension of the spring you would have used in a safety valve?

Ans. I have pretty carefully considered that subject in my testimony in the Crosby case, to which I would respectfully beg leave to refer, and which is to be found on pages 168 and 169 of the record in that case. I may state it a little more succinctly. I should have taken first the area of cross-section of the steam-way, which is the area of the valve exposed to lifting pressure when the valve is closed; second, the supplementary area, free from lifting pressure when the valve is closed, but exposed to the more or less auxiliary pressure whenever the valve is opened. Third, the amount of the lift in vertical measurement which I wished my valve to have when fully opened, and from these data I could have obtained a spring, made according to my directions, which would have pretty nearly met the required conditions. After a trial or two, if not at the first trial, I should have obtained exactly the result I aimed at. Now, in all this there is no special knowledge personal to me. It is general knowledge which every competent mechanical engineer must possess.

It follows, of course, from what I have stated, that each valve would have its own set of conditions. Perhaps I have overlooked some additional conditions, as, for instance, the normal pressure which I wished my valve to work under, and the normal reduction of pressure with which I desired to have it work.

JOHN C. HOADLEY.

STATE OF ILLINOIS, } ss:
County of Cook. }

I hereby certify that John C. Hoadley, the witness above named, having been heretofore sworn in this case to state the truth, the whole truth, and nothihg but the truth, in answer to the questions which might be put to him in the above-entitled suit, was examined and cross-examined by counsel, as hereinabove stated, before me, by consent of the parties, and that this deposition was then reduced to writing and read over by the said witness and signed by him,
345 all of which was pursuant to agreement of Mr. Thomas William Clarke and Mr. J. H. Raymond, counsel, &c.; and that

it was further agreed by them that this deposition should be retained by counsel for the defendant until the time of the final hearing of said cause.

[SEAL.] CHARLES C. LINTHICUM,
Notary Public.

Deposition of John C. Hoadley Continued.

Direct examination by Mr. JAMES H. RAYMOND, of counsel for defendant:

Int. 1. Have you, since your last answer in this case, caused a safety valve to be made purporting to embody the alleged invention of George W. Richardson as set forth in the drawings, specification and claim of letters patent of the United States, No. 58294, granted to said Richardson, dated September 25, 1866?

Ans. I have caused such a safety valve to be made.

Int. 2. Have you examined and measured said safety valve, and compared its form, dimensions, and arrangement with the form, dimensions, and arrangement of a safety valve as the same are set forth in Richardson's said patent of 1866? If yea, please state with what documents you compared said safety valve, and the results of your comparison. Please also produce your said embodiment of said Richardson's invention, and describe the manner in which the same is marked.

Ans. I have made such examination, measurement, and comparison, and now produce my said embodiment of Richardson's patent of 1866, marked on a tag "Defendant's Exhibit Richardson's Patent of 1866, A," and also marked by stamping on the brass case "George W. Richardson, pat'd 1866." There are attached to this exhibit, and intended to be included with it, as designated by said marks, the following appurtenances, to wit:

(1.) A template of sheet copper tinned on one side, showing the angle of the valve-seat at the ground-joint and the form and size of a radial cross-section of the intermediate chamber and of the overhanging lip.

346 (2.) A narrow piece of sheet copper tinned on one side, having a narrow tip of just sufficient thickness to fill the space horizontally between the extended valve-seat and the inner surface of the overhanging lip of the valve, and thus to show the width of the external opening from the intermediate chamber to the open air, now very generally known as a "stricture."

(3.) A brass key for turning the adjusting screw above the spring, to compress the spring to any required degree.

(4.) Two adjusting screws to be used if required in place of the one now in the proper position for use in the exhibit.

The spring now in the exhibit has a compression of ¼ inch for a lifting pressure of 100 lbs. per square inch, and is to be considered as an "ordinary spring," as that term has been defined in this case.

Four several springs, in addition to the one now in place in the above mentioned exhibit, are introduced, and marked as separate exhibits, for convenience of reference, as follows:

"Defendant's Exhibit Richardson's patent of 1866, B," being a spring having $\frac{3}{16}$ inch compression for 100 lbs. pressure per square inch.

"Defendant's Richardson patent of 1866, C," being a spring having $\frac{1}{8}$ inch compression for 100 lbs. pressure per square inch.

The two foregoing are to be considered as "strong springs."

"Defendant's Exhibit Richardson's patent of 1866, D," being a spring having $\frac{5}{16}$ inch compression for 100 lbs. pressure per square inch.

"Defendant's Exhibit Richardson's patent of 1866, E," being a spring having $\frac{3}{8}$ inch compression for 100 lbs. pressure per square inch.

The two last above mentioned springs are to be considered as "weak" springs.

I have here used the terms "ordinary spring," "strong spring," and "weak spring" in the same sense in which I understand Mr. Richardson to use the same terms in the specifications of his patent of 1866; of course, keeping in view the appropriate difference between the action of these direct-acting springs and the "spring
347 or balance" implying the use of a lever, mentioned by Mr. Richardson in the specifications of his said patent.

I have compared my own measurements of said exhibit "Defendant's Exhibit Richardson's patent of 1866, A:"

First. With the dimensions given by Mr. Charles W. Forbes in the Crosby case now in answer to interrogatory 17, evidence for complainants in reply, to be found on pages 332–333 of the record in the Crosby case; which dimensions I have found to be sufficiently accurate save the one numbered 10 on page 333, which, by an obvious error of typography, is made 0.12 instead of .012. This is the area of cross-section of the intermediate chamber radially, the height of which (No. 7) is correctly given as .11 in. and its width (No. 8) .14 in. The upper portion of this cross section is a semicircle of .14 in diameter, and, of course, of .07 radius or height, and having an area of $2 + .07^2 + (\frac{\pi}{4} = .7854) = .0077$ sq. in.

The lower portion of this cross section is a rectangular parallelogram, .14 in. wide + (.11 — .07 = .04) in. high, and its area, therefore, is .14 in. + .04 = .0056 sq. in., and .0077 + .0056 = .0133.

The difference between .012 and .0133 is of no importance; but the above calculation demonstrates the reality of the typographical error which I have pointed out, and justifies, I believe, the correction which I make in adopting Mr. Forbes' dimensions.

The error is further proved by the cubic contents of chamber D with valve closed (No. 11, p. 333), which is given as .0678. Now the diameter at centre of chamber D (No. 9, p. 333) is 1.8 in., and its circumference there $1.8 + \pi = 1.8 + 3.1416 = 5.65488$, and this circumference multiplied by the area of radial cross section, .012 equals .0678. Column 5 of the following table contains Mr. Forbes' dimensions; column 6 contains corresponding dimensions measured by me from a certified copy of Richardson's original drawing filed with his application; column 7 contains corresponding dimensions computed by proportion from Mr. Forbes' dimensions according to the

ratio of the respective diameters of steam-way $\frac{0.99}{1.34}$, equal 0.7388 for linear dimensions. $(0.7388)^2 = 0.5458$ for areas; and $(0.7388)^3 = 0.4033$ for cubic contents.

Nos. 1, 2, 3, 7, 8, 9, 14, and 16, in column 7, are obtained by
348 multiplying the corresponding dimensions in column 5 by the simple ratio 0.7388.

Nos. 4, 5, 6, in column 7, are obtained by multiplying the corresponding areas in column 5 by the square of this simple ratio, equal 0.5458.

No. 10, column 7, is obtained by multiplying the correct number of column 5, namely, .0133, by the square of said ratio, namely, 0.5458. If Mr. Forbes' number corrected were used, namely, .012, the result would be .0065 instead of .0073, a difference of only .0008 sq. in.

Nos. 11, 12, and 13, column 7, are obtained by multiplying the corresponding cubic contents in column 5 by the cube of the simple ratio, namely, 0.4033.

No. 15, in columns 7 and 8, is in each case obtained by direct calculation.

I have added, for convenience, lines 17 and 18, which are obtained directly from the preceding given dimensions.

Column 8 contains corresponding dimensions computed by proportion from my measured dimensions in column 6 according to the ratio of the respective diameters of steam-way, $\frac{0.99}{2.25} = 0.44$ for linear dimensions. $(0.44)^2 = .1936$ for areas, and $(0.44)^3 = .0852$ for cubic contents.

Columns 7 and 8 agree substantially throughout. The dimensions in column 9 are obtained by direct measurement from "Defendant's Exhibit Richardson's Patent of 1866, A," and will be found to agree substantially with columns 7 and 8.

349 TABLE.

1	2	3	4	5	6	7	8	9.
						Exhibit Richardsons Patent of 1866, A.		
		Name of parts mentioned copied from Charles W. Forbes' testimony in the Crosby case, pages 332, 333 of record.	Kinds of quantity.	Forbes' dimensions from heliotype copy of original drawing, pages 332, 333 of the record in Crosby case.	Hoadley's measurements from certified copy of original drawing filed with Richardson's application, 1866.	Proportioned according to Forbes' dimensions in column 5.	Proportioned according to Hoadley's dimensions in column 6.	By actual measurement, J. C. Hoadley.
	1	Diameter of steamway	in.	1.34	2.25	0.99	0.99	0 99
	2	Diameter of valve inside of						
a		lip forming stricture	in.	1.96	3.29	1.45	1.45	1.48
	3	Diameter of upper edge of valve-seat	in.	1.65	2.77	1.22	1.22	1.24
	4	Area of steamway	sq. in.	1.4	3 9760	.7683	.7698	.7698
	5	Area of valve and extended						
b		surface inside of lip	sq. in.	3 017	8.5012	1.6557	1.6548	1.7203
	6	Difference of these 2 areas	sq. in.	1.617	4.5252	.8874	8760	.9505
	7	Height of chamber D above						
c		extended valve-seat	in.	.11	.185	081	.081	.08
	8	Width of chamber D on the line of the top of the valve-seat	in.	.14	.26	.103	.114	.12
	9	Diameter at centre of chamber D	in.	1.80	3.03	1.33	1.33	1.36
	10	Area of end section of cham-						
d		ber D, valve closed	sq. in.	.012	.0408	.0073	.0079	.0080
	11	Cubic contents of chamber D, valve closed	c. in.	.0678	.3884	.0303	.0331	.0342
	12	Cubic contents of chamber D, and extension under valve-seat into steamway;						
e		valve raised 1-16 inch	c. in.	.165	.6712	.0705	.0572	.0594
	13	Cubic contents of chamber D, and extension under valve-seat when valve is raised 1 10 inch	c. in.	.227	.8409	.0915	.0716	.1292
	14	Overlap of lip *c* of the valve						
f		below upper outer edge of valve-seat E	in.	.025	.040	.0185	.0176	.020
	15	Proportion this overlap, as represented in drawings, bears to width for passage of steam between inner						
g		edge of lip *c* and outer cylindrical surface of valve-seat E	ratio	5 to 2	5 to 2	5 to 2	5 to 2	3 6 to 2
	16	Average circumference of space between extended						
h		valve-head and edge of lip *c*	in.	6.126	10.2869	4 5259	4.5262	4.6000
	17	Diameter corresponding to No. 16 *supra*, in middle						
i		of width of stricture	in.	1.95	3.2744	1.44	1.44	1.46
	18	Width of stricture	in.	.017	0156	.013	007	.0156

a, *c*, *f*, *h*, *i*, column 1, denote simple linear dimension in inches; *b*, *d*, column 1, denote areas in square inches; *e*, column 1, denotes cubic contents in cubic inches; *g*, column 1, No. 15, is a ratio.

350 The right-hand column, 9, shows the dimensions of "Defendant's Exhibit Richardson's Patent of 1866" as it actually is, just as nearly as I could measure it.

This exhibit is made with intelligent fidelity, by no means with that blind, servile imitation which I have elsewhere characterized as Chinese fidelity, which would copy accidental defects and extraneous hindrances, but with that higher fidelity which seeks to embody the true design of the inventor in a faultless manner. I have elsewhere spoken of a spirit presumably adverse; and such a presumption doubtless attaches itself to my work as shown in this exhibit. But I have endeavored to overcome such an animus, if such existed, with what success the exhibit will show.

I have added an extended area around "the head of a common safety valve," "about in the proportion shown in the figure,"—exactly in the proportion shown, as nearly as possible. I have terminated "this addition to the head of the valve with a circular or annular flange or lip *c c*, which projects beyond the valve-seat (E E, Fig. 3,) and extends slightly below its outer edge, fitting loosely around it, and forming the circular or annular chamber D D, whose transverse section" is of the form shown in the figure. "This flange or lip *c c*, fitting loosely around the valve-seat E E, is separated from it by about $\frac{1}{64}$ of an inch,"—exactly $\frac{1}{64}$ of an inch, as nearly as it could be made, or measured when made. This is intended for an "ordinary spring," placed directly over the valve, having a compression of $\frac{1}{4}$ inch for a lifting (popping) pressure of 100 pounds per square inch. Although the area of cross-section of steam-way is only 55 per cent. of that of the reduced drawing measured by Mr. Forbes, and only 8.5 per cent.—say $\frac{1}{12}$ of that of Mr. Richardson's original drawing, I have made the width of the stricture exactly as he directs, $\frac{1}{64}$ inch, because a friendly application of my skill and knowledge of the subject so dictates. I have put it into a Kunkle case, partly because that was the least expensive way for the defendant, partly because I wanted this exhibit to compare, in that respect, with other exhibits in this case,—the Webster, Waterman, &c.,—and partly because I thought it would have, in that way, the fairest chance to show for what it is worth. For the same reason

351 I used a direct-acting spring, discarding Mr. Richardson's lever and "spring or balance;" I made numerous and large openings in the case, to give as perfect freedom or discharge to the escaping steam as in an uncovered valve. The exhibit is well made, and would be a useful safety valve in any place where the degree of reduction it gives was desired or not objected to. I had additional springs made, two of them "stronger," and two "weaker," than the one with $\frac{1}{4}$ inch compression for 100 pounds opening pressure per square inch, in order to try the operation of the safety valve with these several springs. The ratio which the "overlap" bears to the width of the stricture, line 15 of the preceding table, is, in Mr. Richardson's patent drawings, as measured by Mr. Forbes from a heliotype reduced copy of the original drawing, and also as measured by me from a certified copy traced from the original drawing, is as 5 to 2, or 2.5 to 1. In "Exhibit Richardson's Patent of 1866" as it ac-

tually is, this ratio is only 3.6 to 2, or 1.8 to 1. That is, if the overlap were in the same ratio to the width of stricture as it is in Mr. Richardson's patent drawings, and the width of stricture, as he says, $\frac{1}{64}$ inch, = .0156 inch, then the actual overlap, in linear measure, would be $\frac{5}{2}$ of .0156 = .039 inch, instead of the .02 inch which it now has, or almost double,—strictly speaking, 95 per cent. greater. This would have increased the reduction of pressure very greatly, so that in diminishing the ratio of overlap to width of stricture, as well as in preserving in this small valve the same width of stricture which Mr. Richardson assigns to a valve 2¼ times as large in diameter of steam-way, I have used a friendly discretion, favorable to the successful working of the valve.

Int. 3. Have you made experiments with said exhibit, with one or more of the springs you have described; if yea, please state the results of such experiments?

Ans. I have made experiments with said exhibit, and with all the springs which I have described, in succession. On the twenty-seventh day of January, 1882, I experimented with said exhibit with the spring now in it, having ¼ inch compression for 100 pounds pressure per square inch. Four separate observations were
352 noted between 3 h. 14 m. 28 sec. and 3 h. 51 m. 30 sec. p. m., an interval of 37 m. 2 sec.

Mean duration of relief, pop to close	5 m. 24 sec.
Mean duration of raising steam	5 m. 9 sec.
Mean interval from pop to pop	10 m. 33 sec.
Mean lifting pressure, lbs. per sq. in.	96.6.
Mean closing pressure	76.8.
Mean reduction of pressure	19.8.
Mean reduction per centum	20.5 per cent.

At the pop the overlap was surmounted and .052 in. more, showing an opening under the lip of the valve above the extended valve-seat of .052 in., by measurement. At that time the valve was lifted from its seat at the ground joint .072 in., vertical measurement.

This opening was very free, and enabled this small valve to relieve the large boiler it was attached to, and to reduce the pressure over twenty per cent. in 5 m. 24 sec.

On the fourth day of February, 1882, I experimented with said exhibit, and the spring marked "Complainant's Exhibit Richardson's Patent of 1866, B," having $\frac{3}{16}$ in. compression for 100 lbs. pressure per square inch; and on February 6 I completed the experiments with the other three springs, C having ⅛ in. compression, D having $\frac{5}{16}$ in. compression, and E having ⅜ in. compression, in each case, for 100 pounds' pressure per square inch. The spring marked D, having $\frac{5}{16}$ in. compression for 100 lbs.' pressure, was somewhat bent, as it now appears, by accidentally and injudiciously applying too much compression, so that the valve popped at 116 lbs. The compression at 116 lbs. was .362 in., and when opened .072 in. more, making .434 in., which brought the coils almost into contact and set the spring a little permanently, and bent it as it now is. Still, it

worked very well when properly set at 100 lbs. The results of experiments with these four springs are given in the subjoined table:

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	Spring B. 3-16 in. compression for 100 lbs.	Spring C. 1-8 in. compression for 100 lbs.	Spring D. 5-16 in. compression for 100 lbs.	Spring E. 3-8 in. compression for 100 lbs.
Number of observations	3	4	2	2
Mean lifting pressure	97.5	98.	100.	98.3
Mean closing pressure	76.6	82.4	68.8	61.
Mean reduction, pounds	20.9	15.6	31.2	37.3
Mean reduction, per cent.	21.5	15.9	31.2	38.2

SUMMARY.

Spring having $\frac{1}{8}$ in. compression for 100 lbs. gives 15.9 p. c. reduction.
" $\frac{3}{16}$ " " 21.5 p. c. "
" $\frac{1}{4}$ " " 20.5 p. c. "
" $\frac{5}{16}$ " " 31.2 p. c. "
" $\frac{3}{8}$ " " 38.2 p. c. "

The least reduction obtained, with a very "strong spring," having only $\frac{1}{8}$ in. compression for 100 lbs. per sq. in. popping pressure, is 15.9 per cent., corresponding almost exactly to the reduction testified to by Mr. Forbes as the best he obtained with the Webster valve as embodied in "Complainant's Exhibit Webster;" an amount of reduction which Mr. Forbes considered wholly inadmissible, and conclusive as to the incompletness of Mr. Webster's invention and the inadequacy of his device. If I am asked whether I considered it proper to confine Mr. Richardson to the exact proportions of his patent drawings, and to judge his invention by a safety valve strictly embodying such exact proportions, I should answer, as much so as in the case of Mr. Webster, and Webster's successor, the public, especially as Richardson refers to his drawings for proportion in the language, "about in the proportion shown," while Webster as distinctly disclaims proportions in the language, "I do not limit mypelf to the precise details herein described and represented, as the same may be varied without departing from the nature of my invention." But I do not think such a course proper in either case, and have, in fact, as I have already explained at much length, exercised a judicious and friendly discretion in so fixing the proportions of stricture and overlap in the exhibit, "Defendant's Exhibit Richardson's Patent of 1866, A," as to be as favorable to its suc-
354 cessful operation as I knew how to make them. And in all details of construction outside of and aside from Richardson's device, such as springs, case, &c., I was equally fair and friendly, quite as much so as in the case of Webster's device.

And yet, while Webster's device, even as embodied in "Complainant's Exhibit Webster," operates well within the quite admissible limits of six to twelve per cent. reduction, and as embodied in "Defendant's Exhibit Webster" at three to five per cent. reduction, Richardson's device, as embodied in "Defendant's Exhibit Richardson's Patent of 1866," gives twenty per cent. reduction with an "or-

dinary" spring and fifteen per cent. reduction with a spring of double the "ordinary" strength—$\frac{1}{8}$ in. compression for 100 lbs. pressure—which, when further compressed by a lift at .072 in., represents a lifting pressure equal to 158 lbs per sq. in.

It may be as well to say that in "Complainant's Exhibit Webster" the extension of the spring at the end of the lever is 2.16 in. for 100 lbs. popping pressure per sq. in., which, as the leverage was 8 to 1, is equal to $2.16 \div 8 = .27$ in. compression of a spring placed directly over the valve. This is about midway between $\frac{1}{4} = .25$ in. and $\frac{5}{16} = .31$ in., and shows that the spring of "Complainant's Exhibit Webster" is about an "ordinary" spring, and that the performance of this exhibit is to be compared with the performance of "Defendant's Exhibit Richardson Patent of 1866, A," with the spring now in said exhibit, having $\frac{1}{4}$ in. compression for 100 lbs. pressure per sq. in., and giving 20.5 per cent. reduction from opening (popping) pressure three or four times as much as "Complainant's Exhibit Webster" gave in my investigation, and one-third more than Mr. Forbes said he found.

If, therefore, on a comparison of these results of a strtct embodiment of the earlier device of Webster with a similar embodiment of Richardson's later device, either of the two is to be declared impracticable, it certainly is not Webster's.

JOHN C. HOADLEY.

(Cross examination waived.)

355 *Evidence for Complainant in Reply.*

Taken pursuant to stipulation.

JOHN A. SHIELDS,
U. S. Com'r, So. Dist. N. Y.

Present: Mr. Thos. Wm. Clarke, of counsel for complainant; Mr. J. H. Raymond, of counsel for defendant.

Deposition of Charles W. Forbes, recalled.

Direct examination by Mr. THOS. WM. CLARKE, of counsel for complainant:

Int. I. Have you heretofore testified in this case, and have you since you testified, and recently, examined the testimony of Mr. Hoadley (John C.), a witness for the defendant, and the exhibits introduced by him to illustrate his testimony, and have you caused experiments to be made under your observation with such exhibits? And, if so, please give the results of your observations on such exhibits and point out any errors in facts or conclusions of Mr. Hoadley which you may have observed which have a bearing upon the scope of the invention of George W. Richardson described in his patent of 1866, and referred to in the claim thereof, or the invention described in his patent of 1869 and referred to in the claim thereof, and to the question of infringement by the Kunkle valves introduced by the complainant in this case.

Ans. I have heretofore testified in this case, and since have carefully reviewed the evidence of John C. Hoadley, an expert witness called by the defendant; noted his criticisms and conclusions.

I have also inspected certain exhibits introduced by said expert witness, purporting to represent the inventions of George W. Richardson referred to in said Richardson's letters patent of the United States No. 58294, dated September 25, 1866; and also letters
356 patent No. 85963, dated January 19, 1869; and also certain other exhibits which Mr. Hoadley, on page 158 of the record, refers to as "certain other safety valves more or less modified from his (Kunkle's) usual practice for the purposes of the experiment, in order to bring out more clearly the function, operation, use, and effect of the several parts of said valves, separately and in combination, and for more distinct comparison of the said safety valves with the patents of Mr. Richardson, as I have shown the same to be limited by antecedently published and recorded invention."

Such safety valves are marked—

"Kunkle Valve, Exhibit A No. 1."
"Kunkle Valve, Exhibit A No. 2"
"Kunkle Valve, Exhibit A No. 3."
"Kunkle Valve, Exhibit No. 4."
"Kunkle Valve, Exhibit B No. 1."
"Kunkle Valve No. 5."
"Kunkle Valve No. 6."

Together with a valve marked "Defendant's Exhibit 3 D," purporting to represent the antecedent invention of James Webster, as illustrated in Fig. 3 of the drawing in said Webster's patent heretofore referred to in this case.

I have also repeated trials of the valve formerly introduced by the complainant in this case, representing this same Webster invention.

I have also caused a safety valve to be made in accordance with the invention of George W. Richardson, as set forth in the drawings, specification, and claim of the letters patent of the United States No. 58294, dated September 25, 1866, and now produce said safety valve, which is labelled "Complainant's Exhibit Richardson's Patent of 1866."

There are attached to this exhibit three several springs; one having a compression of $\frac{1}{4}$ in. for a lifting pressure of 100 lbs. per sq. in., which is to be considered as an "ordinary spring," as that term has been defined in this case; another having a compression of $\frac{5}{16}$ in. for a lifting pressure of 100 lbs. per sq. in., which is to be considered a weaker spring; and another having a compres-
357 sion of $\frac{3}{8}$ in. for 100 lbs. per sq. in., which is to be considered still weaker than the last named.

Springs of less compression than the "ordinary spring" above mentioned are not included, for the reason that the valve is constructed with a stricture $\frac{1}{64}$ of an inch wide for said ordinary spring as directed in the patent, and, as Mr. Richardson states in said patent that said stricture should be smaller for a stronger spring, no means are included in said patent for reducing the size of the strict-

ure; therefore, after the valve was constructed as stated, a stronger spring could not properly be employed with this valve.

With this valve, made in strict accordance with Mr. Richardson's patent of 1866, I made a series of experiments on the thirtieth and thirty-first day of March, 1882, under the best possible conditions as regards quantity and quality of steam, with the following results:

With the ordinary spring having a compression of $\frac{1}{4}$ of an inch for 100 lbs., the valve popped at 100, and closed at 98, showing a reduction of but two per cent.; with a weaker spring of $\frac{5}{16}$ in. compression the valve popped at 100, and closed at 97, a reduction of three per cent.; with a still weaker spring of $\frac{3}{8}$ in. compression the valve popped at 100 and closed at 96, showing four per cent. reduction.

These trials were repeated several times with identical results, and I have never witnessed a more precise and perfect working pop safety valve than this in my whole experience with them.

These experiments were conducted in the presence of James W. Gillies, a constructor of safety valves, in the employ of the Consolidated Safety Valve Company. He made this valve from a tracing attached to a certified copy of Richardson's letters patent of 1866, and he witnessed the measured compression of the springs used, and also witnessed every one of the trials made with this valve.

This valve being made in strict accordance with the drawings of the Richardson patent, no measurements need be here recorded in connection with it, except in reference to those parts which he states in the specification should be of a size mathematically referred to.

For example, we are instructed by Mr. Richardson in said
358 patent that for an ordinary spring the stricture should be about $\frac{1}{64}$ of an inch wide, in connection with the extended area of about the proportion shown in the figure.

Having now given the results of trials with this valve as constructed, without departing from the instructions and illustrations shown in the patent, it does not appear to me necessary to state more than this: that here is the thing, and here is what the thing will do.

I have noted what Mr. John C. Hoadley has said in connection with what he considers a valve made in accordance with said letters patent, and with which he obtained widely different and disproportionate results.

This valve, "Defendant's Richardson Patent of 1866," is not constructed in accordance with the Richardson patent of 1866, but is changed in construction, as Mr. Hoadley states on page 261 of the record, so that the area of cross-section of the steam-way is only 8.5 per cent., or $\frac{1}{12}$, of that of Mr. Richardson's original drawing, while the width of the stricture is exactly as he directs, $\frac{1}{64}$ of an inch. Mr. Hoadley's excuse for the change being, "because a friendly application of my skill and knowledge of the subject so dictates."

Mr. Hoadley also states that he has placed this valve within a Kunkle case for the following stated reasons: "Partly because I wanted this exhibit to compare in that respect with other exhibits in this case—the Webster, Waterman, &c.—and partly because I

thought it would have in that way the fairest chance to show for what it is worth."

In making these changes Mr. Hoadley, as I have before stated, has produced a valve showing great differences in results from those obtained by me with a valve made in strict conformity with the patent, all of which is respectfully submitted without further comment; my acts and conclusions not requiring transcendental mathematics in explanation.

In relation to the Kunkle exhibits introduced by Mr. Hoadley, and referred to on page 158 of the record, the "Exhibit Kunkle Valve A No. 1" is substantially the same as "Complainant's
359 Exhibit Kunkle A" complained of; and "Kunkle Valve Exhibit B No. 1" is the counterpart of "Complainant's Exhibit Kunkle B."

Mr. Hoadley, in connection with these exhibits, omits an illustration of either of them, and also fails to note the various measurements of their construction, from which his allegations concerning the size and proportion of their parts might be determined, with the exception of "Defendant's Exhibit B No. 1," "some of its dimensions" being noted on pages 164 and 165 of the record, this exhibit, however, being the counterpart of "Defendant's Exhibit Kunkle B." An illustration of the valve is herewith attached, and also the illustration of "Complainant's Exhibit Kunkle A," which is the same as "Defendant's Exhibit A 1."

Mr. Hoadley states on page 159 of the record, "This valve has no stricture, nor any mechanical equivalent for the parts which constitute the size of the stricture in the Richardson valve. The opening at the outlet from the annular passage, into which escaping steam flows from the open ground-joint, is at least as large in area as the annular passage itself, even when the valve is seated steam-tight at the ground-joint. It is also larger, even when the valve is seated, than the passage through the ground-joint can ever be when opened to the utmost, and is enlarged by the very opening of the valve in a greater degree than is the opening at the ground-joint, on account of its greater diameter, so that when the valve is most widely open and most freely discharging steam, the widely-parted lips of this gaping mouth are more than twice as far apart as the ground surfaces of the valve-seat."

Now in relation to all this, I will state that in regard to the existence of a stricture such statement is false in fact, and misleading in regard to the connection made between the stricture and the opening at the ground-joint.

I have carefully measured this valve, "Defendant's Exhibit Kunkle Valve A No. 1," and note the same as follows:—

No. 1. Size of valve	1.5	in.
(Diameter of steam-way.)		
No. 2. Areas of steam-way	1.767	"
360 No. 3. Area of valve and supplemental flange within depending lips	3.298	in.

No. 4.	Difference of above areas equal supplemental area	1.531 in.
No. 5.	Area of cross-section of the chamber beneath the supplemental flange, measured between the inner and upper angle of the flange and the lower outer angle of the recess in the valve-casing outside the ground joint	1.89 "
No. 6.	Area or size of the stricture, measured from the inner lower corner of the lip of the supplemental flange to the nearest part of the adjacent flange-casing	.446 "
No. 7.	Difference in areas or size of passage through chamber (1.39) and passage through stricture (.446) in. valve closed	.944 "
No. 8.	Compression of spring at 100 pounds per square inch	.44 "
No. 9.	Extreme lift of the valve while discharging	.07 "
No. 10.	Area of the cross-section of the supplemental chamber, valve open	1.81 "
No. 11.	Area of stricture, valve open	1.11 "
No. 12.	Difference in said areas	.7 "

NOTE.—When the valve is wide open the stricture is transferred to the space between the lower inner corner of the flange lip and the top of the bridge or step, projecting upward from the valve-casing.

As before stated, this valve is substantially the same as "Complainant's Exhibit, Kunkle, Valve A," the only difference observed being a slight variation in the size of the respective strictures—the stricture in defendant's exhibit being .048 smaller than in the corresponding exhibit of complainant. The respective valves operate precisely alike, and the compensation for the difference referred to is found in a corresponding variation in the compression of the springs used—the spring in the defendant's exhibit having a compression of .44 to sustain 100 lbs. per sq. in. pressure, while in complainant's exhibit the spring is compressed to .52, which corresponds
361 with the larger stricture in complainant's exhibit, and is necessary in order to effect the same amount of reduction, as directed by the Richardson patent of 1866.

Mr. Hoadley asserts, first, that "this valve has no stricture nor any mechanical equivalent for the parts which constitute the stricture in Richardson's valve."

This statement is totally incorrect, which may readily be seen by reference to the preceding table of dimensions given of this valve, wherein the size of the passage constituting the stricture is shown to be .944 inches less than the area of the cross-section of the chamber beneath the supplemental flange when the valve is closed, and .7 of an inch less area than the cross-section of the said chamber when the valve is open. This constitutes a stricture—a contracted passage leading from the supplemental chamber to the atmosphere.

In referring to this outlet, technically termed "a stricture" since the introduction of the Richardson valve, Mr. Hoadley associates its size or area with the opening at the ground-joint of the valve, instead of with the size of the intermediate chamber, and states, for a fact, that because said stricture is larger in area than said opening at the ground-joint, that no stricture exists. This is misleading.

The stricture is the outlet leading from the annular chamber beneath the supplemental flange, which is outside the ground-joint or valve-seat, and is invariably larger than the opening at the ground-joint; otherwise the pressure in the chamber would always equal the pressure in the boiler.

In this class of valves that operate within the limits desired in practice, the pressure in the supplemental chamber is fifty per cent. at least, less than the boiler pressure. The ground-joint has no relation whatever to the size of the stricture, and therefore I say that Mr. Hoadley's statement, in referring to such parts, is misleading; and again, that his statement that no stricture exists in the Kunkle exhibit is false in fact.

In regard to "Defendant's Exhibit, Kunkle Valve A No. 1," the change of the structure alluded to by Mr. Hoadley refers to the removal of the bridge or step projecting upward from the valve-seat casing beneath the supplemental flange.

362 Mr. Hoadley states "the result of this alteration is to be seen in the following experiment:"

Experiment No. 12.

Warn slightly at	98 lbs.
Blows, no audible pop, at	100 "
Blows shrill at	103 and 104 "
Blows more shrill at	106 "
Blows, screams, at	107 "
Blows, screams louder, at	107½ "
Blows, screams still louder, at	108 "

And says: "The pressure continually rising for seven or eight minutes; no reduction, but a constant rise, continual shriek, even louder as the pressure rises; but no auxiliary lifting force, or, if any, too little to be of any avail."

"* * * But there is no stricture, no construction, no relative compression, no huddling, and, consequently, no action due to anything to be found in combination or proportions of Richardson's patents, or either of them."

Mr. Hoadley appears to have made the same experiment with a Richardson valve, noted on page 149 of the record, as follows:

Experiment No. 7.

"I then tried this same 'Richardson Valve Exhibit' with a valve in place of one that came with it, having a flange of the same diameter as the one bought with it; but said flange plane, on its lower side, had a height of .12 above the flat part of the seat around the

ground joint, so that there was no stricture whatever, the passage through the expansion chamber being of equal width throughout; that is, one of the walls constituting the side of the stricture is removed in both valves.

"This valve rose at one hundred pounds, continued 'blowing,' without a pop of any sort, for two minutes and ten seconds, the pressure going up at the rate of 14 pounds per minute until it reached 130 pounds, when the experiment was discontinued.

363 "This experiment demonstrates that the theory of Richardson and his expert witnesses, that a stricture is necessary to the operation of his valve, is strictly true." The part removed being an essential part of the structure constituting the stricture in each case, and the results effected by such change being identical and characteristic of the common valve, my statement that a stricture exists in "Exhibit Defendant A, No. 1" should not require further confirmation, nor in relation to the fact that the Kunkle and Richardson valves are the same.

In regard to the change made with "Exhibit Kunkle A, No. 3," the modification consists in turning away the metal of this projecting bridge or step on its outer side so as to reduce it to a thin rim, almost sharp at its upper edge. The effect of this change, Mr. Hoadley states, was to slightly increase the amount of reduction of pressure, the action otherwise being decisive and excellent.

This is precisely the effect I should have conjectured. The change, producing a slight enlargement of the stricture when the valve is seated, does not alter the stricture when the valve is open, because the stricture does not exist at that point when the valve is lifted; but, as I have before stated, it is transferred to the space between the top of the bridge or step (which is left undisturbed) and the depending lip of the flange; and as the flange approaches the seat in its closing action the stricture becomes comparatively larger by the change made, and, consequently, the reduction is greater. This is the whole sum and substance of the matter, and is another illustration of the invention of Mr. Richardson, as set forth in his patent of 1866, for effecting this very thing.

The next exhibit of the defendant referred to by Mr. Hoadley is "Kunkle No. 4." This valve is smaller in size, but no change in its structure is noted. Mr. Hoadley mentioned that the operation of this valve was faultless, and then reiterates as follows:

"There is no stricture, the external opening between the flange of the valve and ring (bridge or step) on valve seat being larger in area, even when the valve is seated, than the opening in the ground joint ever is." Here, again, Mr. Hoadley associates the size of the stricture with the opening of the ground joint; and I here

364 repeat that the statement is misleading, the stricture being the outlet from the larger supplemental chamber, with which, in speaking of the stricture, the relative areas should be compared; and when compared, the opening is smaller than the chamber.

The next exhibit referred to by Mr. Hoadley is "Kunkle Valve B No. 1." This valve is the counterpart of "Complainant's Exhibit Kunkle B," which contains the adjustable screw ring for regulating

the reduction of pressure referred to in the Richardson patent of 1869.

In my former depositions in this case I recorded the results of extensive experiments with this valve. My experiments included trials of this valve with springs of greater or less compression, and with adjustments for the regulating ring to conform to said springs, the effect of which being in strict conformity with the Richardson valve. He appears to have made but one trial with the spring that sustained a compression of .625 of an inch ($\frac{5}{8}$) for a pressure of 100 lbs. per sq. in.

Two other springs accompanied the valve, but it does not appear that he tried but one, which, I should judge from the results, to be the weakest of the lot, for a purpose which I shall presently explain.

My first trial of this valve took place under the conditions given by Mr. Hoadley in his trial, namely, with the spring of $\frac{5}{8}$ of an inch compression, and the ring adjusted below the supplemental flange of valve a vertical distance of .26; the valve operated under such conditions substantially as Mr. Hoadley states; that is, it—

Warned at	101	lbs.
Popped at	101½	"
Closed at	99	"
Reduction of pressure	2½	"

In this position of the adjustable screw-ring no stricture exists between said ring and the supplemental flange, the ring being lowered sufficiently to secure a clear passage to the escaping steam at this point; its area being about one inch greater than the escape passages through the outlets of the case. The outlets in the case consist of three or four small holes bored into the vertical
365 sides of the case, in connection with the escape passage, and in addition to the circumferential slots in the top of the case; the combined areas of said slots and holes being about 1.96 inches. These openings constitute a stricture conforming to the very weak spring used, and the valve necessarily operated with a practical reduction of pressure.

This might appear to be a good action, but the fault lies, under such conditions, in the greatly reduced lift of the valve, the reduction in lift being so great as to practically destroy its efficiency, $\frac{3}{100}$ of an inch; whereas, the lift of the valve, with a proper strength of spring, and a corresponding adjustment of the screw-ring to secure a sufficient pressure beneath the flange to obtain the proper lift, should be, at least, $\frac{16}{100}$ of an inch to make this valve discharge a quantity of steam, when open, proportioned to its size, namely, 2¼ inches diameter. The ring, being lowered in this instance completely outside of the space which it was intended to vary in its range of adjustment, amounts to a useless appendage to the valve. This is inconsistent, because no possible use can be made of it in any position which Mr. Hoadley used it, and no allusion is made by him to the fact that a stricture existed at the openings in the case, or that the efficiency of the valve was impaired on account of

its limited lift, all of which is conclusive to me that the experiment is an endeavor to confuse the mind of the court by a deceptive illustration.

In my former experiments with this valve I went over this same ground, and continued the open adjustment of the screw-ring from 21 notches open, referred to in the sixteenth line of page 20 of my first deposition in this case, up to 122 notches open, within which range of the adjustment no variation in amount of reduction of pressure took place, but a gradual reduction of pressure in the chamber, followed by a comparative reduction in the lift of the valve, the pressure falling in the chamber from 42 lbs. per sq. in. to 7 lbs., and the lift of the valve from $\frac{16}{100}$ inch to less than $\frac{3}{100}$ inch, which demonstrated that the capacity of the valve gradually decreased, and consequent loss of efficiency, so that these peculiarities of the valve under the conditions stated by Mr. Hoadley are not new to me. I am not surprised at the fact, but am surprised
366 to find that Mr. Hoadley represents such fact, and that only in describing this valve.

I then began a series of experiments with this valve, with the springs adapted to the range of adjustment of the screw-ring that the stricture called for, and found in every instance my former results verified.

I substituted the same strong spring having a counterpart of this valve, being "Complainant's Exhibit B," the spring having a compression of $\frac{5}{32}$ (.156) of an inch for 100 lbs. pressure, and adjusted the screw-ring to eleven notches open—the same position indicated on the ninth trial, page 19 of my former deposition—when the valve in operation gave the same results as in the former trial referred to. I then adjusted the ring upward to reduce the stricture to four notches open, the same as in the second trial noted on the same page of my affidavit, and obtained the same results, thereby verifying my former trials with the counterpart of this valve and the same spring.

As I have stated, I went over this same ground in my former experiments, and discarded the results obtained, for the reason that the valve under such conditions was rendered inefficient for commercial purposes, or any other purpose, except, perhaps, the purpose which Mr. Hoadeley put it to.

The subsequent experiments of Mr. Hoadley with "Exhibits Kunkle Valve No. 5, Kunkle Valve No. 6," include a structure of the valve unlike those complained of, all of which are alleged to contain no stricture, but including the same misleading associations that I have hertofore referrred to in relation to the stricture and ground-joint, which do not appear to call for further comment.

I have also carefully reviewed the evidence of Mr. Hoadley relating to antecedent inventions—Mr. Hoadley laying great stress upon the inventions referred to in the English patent granted to James Webster, particularly that modification illustrated in Fig. 3 of his drawings.

I have also noted his comments upon the exhibits representing such invention by the complainant in this case, and have carefully

experimented with the "Complainant's Webster Exhibits," which are accepted by Mr. Hoadley as a correct representation of
367 said invention, and find that my former statement in regard to the operation of such valve is confimed.

I have never regarded this valve as worth especial notice; my former reference to it has been brief, and I would not at this time extend my criticism in the specific manner following, except to refute the statement by Mr. Hoadley in regard to the results obtained by him in conneceton with it.

This invention of James Webster is not only practically inoperative, but differs from the Richardson invention in operating under a different structure and method of adjustment.

If I understand Mr. Hoadley's statements in regard to this valve, the only question upon which we differ relate to the facts concerning its operation and comparative organization and method of adjustment with the Richardson valve.

In regard to the first question, that of efficiency, I find that the valve is incapable of working in an acceptable manner within twelve per cent. of the amount reduction allowable in practice.

I have made very careful experiments with this valve, and the best results obtained by me as regards amount of reduction of pressure were in a trial in which the lower edge of the adjustable flange shown in Fig. 3 was set at .0084 inch below the top of the surrounding casing:

The valve warned at	88 lbs.
Popped at	100 "
And closed at	88 "

showing a reduction of 12 pounds, or 12 per cent.; and in no other position of this flange could so acceptable an action of this valve be prodoced; and in regard to this point, wherein Mr. Hoadley states in his 90th experiment, recorded on page 211 of the record, that from the third trial he obtained a mean reduction of 5.9 per cent. and obtained certain and precise results, I wish to challenge such statement, and to say that it is incorrect.

The results obtained by me are a slight improvement upon those found in my former experiments of this valve, with the exception of the amount of warning indicated, for the reason that I have
368 in this instance taken the utmost pains to operate this valve so as to obtain the best results possible in this, that I have operated the valve under a sudden rise of the pressure, and under a very slow and gradual rise of the pressue preceding the pop action, and also with a sudden decrease and a slight and constant decrease of pressure following the opening of the valve. The best results were obtained by allowing the pressure to slowly and gradually increase to opening pressure, and when the valve opened, as slowly and gradually to decrease to the closing point.

Below twelve per cent. reduction of pressure this valve operates decisively, with the exception that in every instance, at whatever point of adjustment the flange may be set, the valve gives the un-

usual warning of from 12 to 15 pounds below the opening pressure. In these trials with this valve, the adjustment and the operation of the valve were witnessed by Mr. Gillies, who will corroborate my statement in this respect; and, as I said before, I challenge Mr. Hoadley, or any other man, to improve upon the results obtained by me.

Now an investigation of the construction of the Webster valve, and his method of adjustment as compared with Mr. Richardson's, should be enough to convince any fair-minded person that it is not the same invention, and that said Webster's construction is based upon false mechanical principles, in considering the element it is designed to control, particularly in the manner demanded in this class of valves.

In the first place, the supplemental chamber in the Webster valve is misplaced; instead of being confined to that portion of the supplemental flange or additional surface that is effected, it is spread over the entire upper surface of the flange, and produces a reactionary effect of the steam upon the valve itself, and thereby huddles steam in useless quantity.

In the second place, the method of adjustment is not applied exclusively to the stricture, as in the Richardson invention, but to a vertical elevation of the flange that varies the chamber in capacity.

Webster's method of adjustment is made with a slight, and a very slight, vertical adjustment of his supplemental flange, pro-
369 ducing wide differences in the results or in the amount of reduction of pressure, while in practice such conditions should be exactly the reverse.

The most infinitesimal vertical movement practically attainable with this flange will vary the amount of reduction of pressure, at the best possible working point of the valve, five per cent.; such a difference in the amount of reduction of the pressure being attainable with .0014 inch vertical adjustment of the flange, while in other portions with the range of adjustment of the flange, a variation of .038 inch in vertical adjustment changes the amount of reduction 32 per cent.

Now with means, as shown in his patent, for effecting such micrometer adjustments, consisting of a smooth valve stem upon which the supplemental flange is intended to be moved vertically, and fastened with a set-screw, no precision or certainty is possible.

His method required further means like, for example, such as adopted for the purposes of this case, namely, a threaded stem, in order to even show a possibility in the action of the valve, and which, with all this addition, places this valve outside of the capabilities of the Richardson valve, or of the demand of the purpose intended, without even a suggestion from Mr. Webster that any other means were necessary than those shown.

Another very serious defect in this Webster contrivance is that the escaping steam from the boiler strikes the flange with direct impact and in the line of adjustment of the flange, rendering it liable to displacement, which would result in accumulating or over pressure in the boiler if it was moved in the slightest degree in one direc-

tion, and a loss of a very large portion of the working pressure if moved in the opposite direction; and Mr. Hoadley's attempts to operate this valve as Mr. Webster made it confirm my statement as to its liability to an accident of this nature. He states, in regard to a Webster valve which he made and closly copied from the patent drawing, that the flange on the valve-stem was actually misplaced in operation, and that the devices shown by Mr. Webster were incapable of even securing the parts, to say nothing of their incapacity for the adjustment required. This is very good evidence to
370 me that James Webster never constructed one of his valves for practical operation.

Mechanical contrivances that are required to regulate or indicate definite things from a source of uncertain motion are not organized and arranged in a manner like that found in the adjustable feature of the Webster invention. For instance, the application of hand-power to a desired movement intended to be proportionately indicated at a distant point through intervening mechanism should not be increased, as, for example, through a train of gears, to obtain an approximate movement, for the reason that an error in the uncertain movement of the hand would be multiplied at the point indicated; while, on the contrary, the reverse operation should be adopted. The former indefinite and unmechanical system appears in this Webster method of adjustment, giving, in addition to other disqualifications, evidence of the want of the knowledge requisite to solve this problem relating to pop safety valves.

The exhibits introduced by the defendant in this case, purporting to represent the Webster invention, have been changed in various ways; such valves, however, are not Webster's valves, and I will not criticise a cheat exhibit, but leave the burden of proof upon its maker to sustain it.

This Webster method of adjustment is not found in any of the subsequently successful valves of this class, and probably never will be, notwithstanding Mr. Hoadley states, on page 156 of the record that while it is a different it is a better form of regulator than Richardson's.

In regard to the Ritchie valve Mr. Hoadley alleges that the stricture is therein "found to be perfectly developed" (p. 142). This I deny. The existence of a stricture in the Ritchie valve is entirely inconsistent with his described theory—that of comparative areas to effect variations in the amount of reduction of pressure—and I may add right here that such theory may be properly classed with the Webster method in point of practicability.

The Waterman, Hartley, and Green valves, described in their respective patents, are all failures, and need alteration and reconstruction in kind and degree to convert them into acceptable pop
371 safety-valves, as, for example, I have illustrated with a Ritchie valve, referred to on page 9 in my first deposition in this case, in reference to plate 3, and the conversion must include the incorporation of Richardson's invention, either by selecting the strength of spring conformable to accidental strictures existing, or by adding the latter absolutely. If Mr. Hoadley has succeeded in operating any

of these antecedent valves within the limits demanded in practice, he has adopted either one or both of the above-mentioned expedients which constitute the *res gesta* of Richardson's invention.

Int. 2. In the instruments produced as illustrations of the Hartley, Waterman, and Webster valve by the defendant, have the directions of those three patents been followed in the construction and fitting up of the valves? And, if not, please point out what variations have been made, and what effects have been produced by these variations; and are any, and what, instructions given in said patents leading to these variations?

Ans. With the instruments referred to in the questions, the directions in the patents relating to them, as regards construction and fitting up, have not been followed, but have been varied in accordance with Mr. Hoadley's friendly application of skill which the respective subjects dictated; and, in connection with such changes Kunkle cases have been added, or, I should say, cases that were once Kunkle's, but now are honeycombed with holes, which, he says, are intended to permit a free escape of the steam, but which may be useful for other purposes, such as diverting a portion of the current of steam, or changing its course to effect more or less retardation, or for the purpose of increasing the reaction beneath the supplemental surface, or causing it to reach upon the top of the valve, thereby augmenting its load, and all to effect some desired result in its operation, which, as I have shown, this Kunkle case is capable of.

Another circumstance I observed in connection with all this is that Mr. Hoadley has selected springs of extraordinary tension, far greater than would be necessary in a valve of this kind properly organized, and far greater than such valves can efficiently operate under. For instance, with the Webster exhibit Mr. Hoadley
372 selects a spring of but $\frac{11}{100}$ of an inch compression for 100 lbs., with the Hartley exhibit $\frac{13}{100}$ of an inch, and with the Waterman exhibit $\frac{7}{100}$ of an inch.

The effect of such selections of spring of so slight a degree of compression is, in nearly all cases, to so limit the lift of the valve as to render it ineffectual in discharging a proper quantity of steam proportionate to its size.

It is well understood, since Mr. Richardson in his patent has informed us of the fact, that, with a given size of spring, the opening and closing action of these valves may be affected in any desirable manner by doing this very thing.

No instructions to adopt such expedients are given in either the Hartley, Waterman, or Webster patents, the Hartley patent omitting reference to any kind of spring whatever.

I have not tested these valves, as they do not represent the inventions they are stated to represent, and therefore I do not know whether they will act as Mr. Hoadley says; and if I did try them and find that they would give the results stated, it would only confirm my conviction that they constitute a cheat and a swindle.

Mr. Hoadley himself, in his examination in the Crosby case in May, 1880, for the first time learned that such springs of short compression or of great stiffness were required for these valves to give

them the appearance of working, and said at that time that he was not aware that any such spring had been actually used, and had no idea that any such spring in common use could be successfully applied.

CHARLES W. FORBES.

Cross-examination by Mr. J. H. RAYMOND, of counsel for defendant:

Cross-int. 3. Mr. Forbes, I have temporarily in my control a pamphlet belonging to a private library, which I must immediately return, and which I now hand you; please state what it purports to be, and the evidences which you find in it of its date of publication, and please also quote from it the third paragraph of the letter-press.

373 Ans. The pamphlet purports to be "Lectures De Potentia Restitutiva," or of spring, explaining the power of springing bodies; to which are added some collections, &c., by Robert Hooke, S. R. S., printed in London in the year 1678. And the paragraph referred to is as follows:

"About two years since I printed this theory in an anagram at the end of my book of the 'Descriptions of Helioscopes,' viz., *c e i i i n o s s s t t u u, id est ut tensio sic vis;* that is, the power of any spring is in the same proportion with the tension thereof." I find also published in the same book the law of the spring balance enunciated under the following anagram: *c d e i i n n o o p s s s t t u u,* namely, *ut pondus sic tensio.*

Cross-int. 4. In a valve made in accordance with the Richardson patent of 1866, having a diameter of steam-way .99 and area of steam-way .7698, what per cent. of the area of cross-section of the steam-way of the original drawings of the Richardson patent of 1866 is the area of cross-section of steam-way of such a valve?

Ans. 19.39 per cent.

Cross-int. 5. That is to say, about one-fifth?

Ans. Yes, sir.

Cross-int. 6. Then in your quotation from page 261 of this record, to wit, Mr. Hoadley's testimony in this regard, instead of saying that "the area of cross-section of the steam-way of the Richardson valve" (with which he experimented) "is only $8\frac{5}{10}$ per cent., or $\frac{1}{12}$ of that of Mr. Richardson's original drawing," the record, to be accurate and accord with the dimensions given by Mr. Hoadley of that valve, should read, that the area of cross-section of the steam-way is 19.39 per cent., or one-fifth of that of Mr. Richardson's original drawing, should it not?

Ans. It should.

Cross-int. 7. Will you please make accurate measurements of the valve marked "Complainant's Exhibit Richardson Patent of 1866," with which you have experimented, as per your direct examination in reply, and making a table to be appended to this your cross-examination, showing for the said valve—

First. The diameter of the steam-way when the valve is closed.

374 Second. The diameter of the valve inside of the lip forming the stricture.

Third. The area and extended surface inside of the lip or flange.

Fourth. The amount of overlap of the lip or flange as the said valve was experimented with.

Fifth. The cubic contents of the supplemental chamber.

Sixth. The diagonal width of the ground-joint, and also the superficial area of the same.

Seventh. The area of the stricture.

Eighth. The cubic contents of the supplemental chamber, not including the steam-way or ground-joint.

Ans. I have made such measurements, and I append such table, as follows:

1. Diameter of steamway, valve closed	2.25″
2. Diameter of valve inside lip forming stricture	3.281″
3. Area of valve and extended surface inside of the lip or flange	8.45″
4. Amount of overlap	.034+
5. Cubic contents supplemental chamber (valve open $\frac{1}{16}$)	.67″
6. Diagonal width ground-joint	.32+
Area of same	1.96′
7. Area of stricture	.16
8. Cubic contents supplemental chamber, valve seated	.388

Cross-int. 8. Will you please explain a little more fully item number 10 of your measurement of "Defendant's Exhibit Kunkle Valve A, No. 1," which reads, "Area of the supplemental chamber, valve open, 1.81," and state how you arrived at those figures.

Ans. Referring to item number 5 of the same table, the area of cross-section of the chamber beneath the supplemental flange, which was taken with the valve closed, is stated as 1.37 inches. Item number 9 refers to the extreme lift of the valve while discharging as .07 inch. This amount of lift of the valve when open is added to the vertical measurement of the chamber and multiplied by its mean circumference, the result being stated in item number 10
375 referred to as 1.81 inches, which amounts to an increase in the size of cross-section of the chamber when the valve is open wide of .427.

Cross-int. 9. What, Mr. Forbes, are the extremes of the vertical lifts of the spring safety valves with which you have ever experimented?

Ans. With the Richardson and other types of practical "pop" safety valves, the extreme lifts in such valves while discharging a quantity of steam proportioned to their size is generally between one-eighth and one-sixteenth of an inch. I have observed variableness between such amounts.

Cross-int. 10. What dimension or proportion does the Richardson patent of 1866 give for the supplemental chamber?

Ans. "To the head of the common safety valve, indicated by all that portion of Fig. 2 lying within the second circle from the common centre, add what is indicated by all that portion lying outside

of the said circle, in about the proportion shown in the figure. A transverse vertical section of this added portion is indicated in Fig. 4 by those portions of the figure lying outside of the dotted lines *pp, pp,* while all that portion lying within the dotted lines *pp, pp,* indicates a transverse vertical section of the common safety valve alone. * * * I terminate this addition to the head of a valve with a circular or annular flange or lip, *c c,* which projects beyond the valve-seat E E, Fig. 3, and extends a little below its outer edge, fitting loosely around it, forming a circular or annular chamber, D D, whose transverse section shown in the figure may be of any desirable form or size." The words quoted appear to include all reference in the patent to the dimensions and proportions of the supplemental chamber.

Cross-int. 11. Do you find in the language quoted, or in any other language in this patent, any definite instructions as to the proportions between the dimension of the supplemental chamber and the stricture, or as to the proportions between any dimension of the supplemental chamber and the tension of the spring?

Ans. I do find in these words quoted, and in other portions of the descriptive matter of the patent, sufficient data and reference to the respective patents, which, taken in connection with the drawings attached to the patent, will enable me, or any person skilled
376 in the art, to construct a valve in accordance with Mr. Richardson's invention.

Cross-int. 12. (The last interrogatory repeated.)

Ans. The patent directs in the words quoted that the supplemental chamber should be contained within certain vertical lines indicated by letters of reference in one or more figures of the drawing, the form of the chamber also being plainly shown in the respective figures; for the size of valve shown in the figures, the size of the stricture is given as $\frac{1}{64}$ of an inch, I believe, and the tension of the spring is referred to as "ordinary." With this data, in reference to these respective parts, sufficient information is included to enable me, or, in my judgment, any person skilled in the art, to construct a valve of the dimension and proportion given.

Cross-int. 13. Do you desire to add anything more definite as to the dimension inquired of than is contained in your two answers to the last question?

Ans. No; I think I have stated in effect that the patent, in referring to any of its essential parts, is sufficiently full and exact.

Cross-int. 14. I understand you to state in your direct examination in reply, that you are of opinion that if in a spring safety valve the size of the opening at the ground-joint be less than the size of the opening through which the steam escapes to the valve case or atmosphere, but the size of the intermediate chamber be greater than the size of said opening to the case or atmosphere, a stricture is thereby created within the meaning of the Richardson patent of 1866; am I correct?

Ans. Most certainly correct, sir.

CHARLES W. FORBES.

Attest:

F. F. RAYMOND, 2d, *Sp'l Ex'r.*

377 *Assignments.*

Liber D[10], p. 86.

TROY, *January* 10, 1868.

This agreement, made this the tenth day of January, 1868, between George W. Richardson & Co., of the first part, and Starbuck Brothers, of the second part, witnesseth: The parties of the second part agree to manufacture and sell safety valves of George W. Richardson's patent under the following terms, viz: They to manufacture such valves at a fair and reasonable price for labor and material, such price to be such sum as shall be agreed upon by George W. Richardson and George H. Starbuck, in the month of March in each year; and provided no such agreement be had during such month of any year, the price of manufacturing for the year following shall be and remain the same as for the year past. And for all valves sold by said parties of the second part, the selling prices are to be, for two inch valve, fifty dollars ($50); for two and one quarter inch valve, sixty dollars ($60); for two and one half inch valve, seventy dollars ($70); and for three inch valve, eighty dollars ($80); said selling prices of valves not to be varied from, except the parties of the second part are to be allowed the privilege of giving to their agents the sum of ten per cent. for selling, which shall be deducted from said prices in accounting for said valves, unless such variation or price may be fixed from time to time as may be mutually agreed upon by George W. Richardson and George H. Starbuck, the net proceeds of such sale over the price of manufacturing, with the deduction of said ten per cent. for agents' fees, as above named, to be equally divided between said parties of the first part and said parties of the second part; and for such safety valves as may be disposed of by said parties of the first part, they are to pay the parties of the second part, if sold to be used outside the State of New York, the manufacturing price as agreed upon above. If sold within the State of New York, they are not to be sold less than the prices agreed upon above, viz., fifty, sixty, seventy, and eighty dollars, on
378 which they are to be allowed ten per cent. for selling, and the balance, or the net proceeds above the price of manufacturing, and such percentage to be equally divided between the parties of the first part and the parties of the second part.

The said parties of the first part guarantee to the said parties of the second part the exclusive right to manufacture and sell said safety valve, with all improvements that may be hereafter patented during the existence of such patents, within and for the State of New York. Said parties of the second part hereby agree to make such safety valves in sufficient quantities to supply the demand for the same in said territory, and in case of failure on the part of the parties of the second part to supply such demand at a reasonable notice or time after such valves may have been ordered, then this contract or agreement to be void and of no force. The parties of the second part are also to have the right to sell and dispose of said valves in any and all such territory in the United States outside of the State of New York, until such territory may be sold or disposed

of by said parties of the first part, of which due notice of such sale shall be given to the parties of the second part; said privilege to extend only to the application of such valves to boilers used for stationary engines and other stationary purposes, and when applied to marine engines. Nothing in the above contract to give the parties of the second part the right to apply to boilers used by railroad companies for their locomotives or for other engines used by them in their business. The parties of the second part also agree not to engage or interest themselves in the manufacture or sale of any other patent safety valves.

The settlement of sales of said valves to be made by both parties on the tenth of each and every month, and the books of said parties to be open for the inspection of the other parties of both the first and second parts, as far as may relate to the sale of such valves, at any and all reasonable times.

Signed this tenth day of January, 1868.

GEO. W. RICHARDSON & CO.
STARBUCK BROTHERS.

379 Witnesses:
PHILIP A. DENEL.
CHARLES S. SMITH.

[5-cent int. rev. stamp, cancelled.]

Recorded February 6, 1868.

Liber O[10], p. 199.

Whereas George W. Richardson, George Gould, William H. Poor, and Henry Waterman, constituting the firm of George W. Richardson & Company, of Troy, in the State of New York, are the proprietors of certain letters patent granted by the United States of America to George W. Richardson, dated September 25, 1866, for an improvement in safety valves for steam boilers, number of patent 58294: Now, know all men by these presents, that we, the said George W. Richardson, George Gould, William H. Poor, and Henry Waterman, constituting the firm of George W. Richardson & Company, for and in consideration of the sum of three thousand and six hundred dollars, paid and to be paid by the Michigan Central Railroad Company, of which amount the sum of twenty-three hundred dollars is hereby acknowledged, the balance, viz., thirteen hundred dollars, to be paid when the said improvement in safety valves are attached to fifty boilers belonging to the said Michigan Central Railroad Company, the receipt whereof is hereby acknowledged, do hereby authorize and license the said Michigan Central Railroad Company, their successors and assigns, to manufacture, construct, and use, for and during the whole term for which the said letters patent have been granted, and any extensions and renewals thereof, the said patented improvement and any additions or improvements thereon made or hereafter to be made by any of us upon boilers, stationary or locomotive, now or hereafter to be used upon the railroad of the said Michigan Central Railroad Company, and upon any

and all branches and extensions of said road which said company now own or operate, or may at any time hereafter own or operate, or lease or run in the States of Michigan or Indiana or Illinois. And we do hereby release the said Michigan Central Railroad Com-
380 pany from all claim for past infringement, if any, of the said letters patent.

In witness whereof, we have hereto set our hands and seals this twenty-third day of May, A. D. 1868.

GEO. W. RICHARDSON. [SEAL.]
GEO. GOULD. [SEAL.]
HENRY WATERMAN. [SEAL.]
WM. H. POOR. [SEAL.]

Sealed and delivered in presence of—
To first three signatures:
A. D. LYON.
J. LANSING LANE.

To fourth signature:
H. E. SARGENT.
P. JETSON.

[5-cent int. rev. stamp, cancelled.]

Recorded June 5, 1868.

Liber T[10], p. 190.

This agreement, made the first day of December, 1866, by and between George W. Richardson, of the city of Troy, in the county of Rensselaer, and State of New York, and the firm of George W. Richardson & Co., consisting of said George W. Richardson, George Gould, and William H. Poor, witness: That said George W. Richardson has obtained letters patent of the United States of America, for a new and useful improvement in steam safety valves, which letters patent are dated the twenty-fifth day of September, in the year eighteen hundred and sixty-six, and are numbered 58294; and that said George W. Richardson, in consideration of the agreement of said firm that he, said Richardson, is to receive for his own use one half of the net profits of the business of said firm, has granted, sold, transferred and assigned, and by this instrument does grant, sell, transfer and assign, to the said firm, the said letters patent, and all the rights, interests, benefits, and advantages to him granted and assured by said letters patent; to have and to
381 hold the same to said firm, and the heirs, personal representatives and assigns of the members thereof, for and during the full end and term of the existence of said patent, and any renewal or extension thereof.

In witness whereof, I, the said George W. Richardson, have hereto set my hand and seal, the said first day of December, A. D. 1866.

GEO. W. RICHARDSON. [SEAL.]

In presence of—
J. LANSING LANE.

[5-cent int. rev. stamp, cancelled.]

STATE OF NEW YORK, } ss:
Rensselaer County, }

On this twenty-second day of August, 1868, before me personally appeared George W. Richardson, to me known to be the person described in and who executed the assignment above, and acknowledged the due execution thereof by him for the uses and purposes therein mentioned.

[SEAL.] JOHN F. CALDER, *Notary.*

Recorded August 24, 1868.

Liber E[11], p. 84.

Whereas the undersigned, George W. Richardson, George Gould, William H. Poor and Henry Waterman, constituting the firm of George W. Richardson & Company, of Troy, in the State of New York, are the owners and proprietors of certain letters patent granted by the United States of America to George W. Richardson, dated September 25, 1866, for an improvement in steam safety valves for steam boilers, number 58294, and assigned by the said George W. Richardson to George W. Richardson & Co., consisting as aforesaid, by assignment bearing date the first day of December, 1866, recorded in the Patent Office of the United States at the city of Washington, on the twenty-fourth day of August, 1868, in liber T[10], page 190, of transfers of patents;

And whereas the said George W. Richardson, George Gould,
382 William H. Poor, and Henry Waterman, constituting the said firm, are the owners and proprietors of certain letters patent granted and issued by the United States of America to Henry Waterman, dated November 15, 1853, number 10243, of which last-mentioned letters patent a reissue was made, dated July 9, 1867, number of reissue No. 2675, for an improvement in safety valves, and said Henry Waterman has also obtained an extension of said letters patent and the reissue aforesaid for the period or term of seven years from the 15th day of November, 1867, which extension bears date the 26th day of March, 1868, which said last-mentioned letters patent and reissue were assigned by the said Henry Waterman to the said George W. Richardson & Company, constituted as aforesaid, by assignment, bearing date the 19th day of July, 1867, recorded in the Patent Office of the United States, at the city of Washington, on the 24th day of August, 1868, in liber T[10], page 199, of Transfers of Patents, and which said last-mentioned letters patent, reissue, and extension were assigned by the said Henry Waterman to the said George W. Richardson & Company, constiuted as aforesaid, by assignment, bearing date the 30th day of March, 1868, recorded in the Patent Office of the United States, at the city of Washington, on the 24th day of August, 1868, in liber X[10], page 163, of Transfers of Patents;

And whereas Collis P. Huntington, of the city, county, and State of New York, is desirous of acquiring an interest in said patents, reissue, and extension:

Now this indenture witnesseth, that we, the said George W. Rich-

ardson, George Gould, William H. Poor, and Henry Waterman, constituting the firm of George W. Richardson & Co., for and in consideration of the sum of four thousand five hundred dollars, to us in hand paid by the said Collis P. Huntington, the receipt whereof is hereby acknowledged, have granted, sold, assigned, set over, and conveyed, and by these presents do grant, sell, assign, set over, and convey unto the said Collis P. Huntington, all the right, title, and interest which we and each of us have in and to the said inventions, as secured by said letters patent, reissue, and extension, and any and all extensions, reissues, and renewals of said patent, and
383 any and all additions and improvements made, or hereafter to be made, by any or either of us to said patented improvement upon all boilers, locomotive, steamboat or stationary, now or hereafter to be used for, to, and in the States of California, Oregon, and Nevada, and all other States, and also all Territories and parts of States and Territories of the United States lying west of the Rocky Mountains, excepting that portion of the Pacific railroad built or which shall be built by the Union Pacific Railroad Company, and also excepting the right of the Government of the United States to use on Government vessels or on stationary engines in Government buildings, the same to be held and enjoyed by the said Collis P. Huntington for his own sole and exclusive use and behoof, and for the sole and exclusive use and behoof of his legal representatives and assigns, for the full end of the term for which said letters patent are granted, and for the term of any extensions thereof, as fully and entirely as the same would have been held and enjoyed by us had this grant and sale not been made.

And we do hereby covenant, promise, and agree to and with the said Collis P. Huntington that we are the lawful owners of said letters patent and inventions, and that we have not encumbered the premises hereby conveyed, or given or granted any right or license for the manufacture or use of said improvement or premises hereby granted in any of said States or Territories, excepting to the Union Pacific Railroad Company for use upon their railroad.

And we do further agree that the above-mentioned consideration of four thousand five hundred dollars includes the royalty for said valves applied and to be applied to ten locomotives built and being built at the Schenectady Locomotive Works for the Central Pacific Railroad Company of California; also to patterns for locomotive, steamboat, and stationary valves, and drawings for making proper tools for constructing said valves; and that the said Collis P. Huntington, his executors, administrators, and assigns, is and are, for the consideration aforesaid, hereby authorized and licensed to use the said improvements, and cause the same to be manufactured, put upon and used on all locomotives, steamboats, and stationary engines built or to be built at Schenectady or elsewhere east of
384 the Rocky Mountains, for the said Collis P. Huntington, or his assigns, which are to be used by him or them, or by any company in which he or they are interested west of the Rocky Mountains.

And we do hereby release the said Collis P. Huntington and his

executors and administrators from all claim for past infringement, if any, of the said letters patent, reissue and extension; and we do hereby covenant and agree to and with the said Collis P. Huntington, his executors, administrators, and assigns, at any and all times hereafter, to execute and deliver to the said Collis P. Huntington, his executors, administrators, and assigns, at his and their request, all such further conveyances and assurances of said letters patent, or any reissues, extensions, or renewals thereof, as shall be required, and to warrant and defend the sale of the said interest in said patent and invention against all and every person and persons whomsoever.

In witness whereof, we have hereunto set our hands and seals the first day of October in the year one thousnd eight hundred and sixty-eight.

GEO. W. RICHARDSON. [SEAL.]

[5 cent int. rev. stamp, cancelled.]

GEO. GOULD. [SEAL.]
W. H. POOR. [SEAL.]

[5-cent int. rev. stamp, cancelled.]

HENRY WATERMAN. [SEAL.]

[5-cent int. rev. stamp, cancelled.]

Signed, sealed, and devered in presence of (the word "September" interlined on first page before execution, and the words "or on stationary engines in Government buildings," on third page, interlined before execution—

GEO. A. STONE.
J. LANSING LANE.

STATE OF NEW YORK, } ss:
Rensselaer County, }

On this tenth day of November, 1868, before me personally appeared George W. Richardson, George Gould, W. H. Poor, and Henry Waterman, to me severally known to be the same
385 persons named in, and who executed, the foregoing instrument, and, each for himself, acknowledged the due execution thereof.

[SEAL.]

GEO. A. STONE,
Notary Public, Troy, N. Y.

[5-cent int. rev. stamp, cancelled.]

Recorded November 12, 1868.

Liber X[11], p. 233.

TROY, RENSSELAER COUNTY, N. Y.,
May 1, 1869.

This agreement, made this the first day of May, 1869, between George W. Richardson & Co., of the first part, and Starbuck Brothers, of the second part, witnesseth: That for and in consideration of the sum of one thousand dollars, receipt of which is hereby ac-

knowledged, the said parties of the first part do grant, convey, and sell to the parties of the second part the exclusive right to manufacture and sell George W. Richardson's patent safety valve for and in the State of Ohio, upon the same terms and upon the same conditions as is contracted for by the parties of the first and second part for the manufacture and sale of said valve for the State of New York, said contract having been made upon the tenth day of January, 1868, and recorded in the Patent Office February 6, 1868, and recorded in liber D^{10}, page 86, of Transfers of Patents.

GEORGE W. RICHARDSON & CO. [SEAL.]
STARBUCK BROTHERS. [SEAL.]

[5-cent int. rev. stamp, cancelled.]

Witness:
P. A. DEUCK.
WALTER STARBUCK.

Recorded July 10, 1869.

386 Liber G^{16}, p. 97.

The following certified copy of an assignment is recorded by order of the Commissioner of Patents, it being alleged that the original asssignment was stolen:

[5-cent int. rev. stamp, cancelled.]

Whereas George W. Richardson, George Gould, William H. Poor, and Henry Waterman, constituting the firm of George W. Richardson & Co., of Troy, in the State of New York, are the proprietors of certain letters patent granted by the United States of America to George W. Richardson, dated September 25, 1866, for an improvement in safety valves for steam boilers—

Now, know all men by these presents, that we, the said George W. Richardson, George Gould, William H. Poor, and Henry Waterman, constituting the firm of George W. Richardson & Co., for and in consideration of the sum of twelve hundred and fifty dollars paid and to be paid by the Burlington & Missouri River Railroad Company, of which amount three hundred dollars has been paid, the receipt of which is hereby acknowledged, the balance to be paid as follows, to wit, for every additional boiler more than twelve (12) the sum of twenty-five dollars per boiler, at the time the said improvement in safety valves shall be attached to boilers owned and used by said railroad company until the whole of said sum of twelve hundred and fifty dollars shall have been paid, the receipt whereof is hereby acknowledged, do hereby authorize and license the said Burlington & Missouri River Railroad Company, their successors and assigns, to manufacture, construct, and use for and during the whole term for which the said letters patent have been granted, and any extension and renewals thereof of the said patented improvements, and any additions or improvements thereon made, or hereafter to be made by any of us, upon all the boilers, stationary or locomotve, now or hereafter to be used upon the railroad of the said Burlington & Mis-

souri River Railroad Company, and upon any and all branches and extensions of said road which said company may own or operate, or may at any time own or operate.

And we do hereby release the said Burlington & Missouri
387 River Railroad Company for all claim for past infringement, if any, of the said letters patent.

In witness whereof, we have hereto set our hands and seals this twenty-ninth day of May, 1868.

GEORGE W. RICHARDSON.
GEORGE GOULD.
HENRY WATERMAN.
WILLIAM POOR.

Sealed and delivered in presence of—
A. D. LYON.
J. LANSING LANE.
J. M. HORTON.
J. T. GODDARD.

STATE OF IOWA, *County of Des Moines:*

I hereby certify that the foregoing is a correct copy of an assignment of interest *of interests* in and to the invention therein mentioned, executed by George W. Richardson, George Gould, William H. Poor, and Henry Waterman, to the Burlington & Missouri River Railroad Company, dated Burlington, Iowa, November 9, 1872.

GEO. O. MANCHESTER,
[SEAL.] *Notary Public in and for said County.*

Recorded November 18, 1872.

Liber A[23], p. 343.

Whereas George W. Richardson, of Troy, in the county of Rensselaer and State of New York, did obtain letters patent of the United States for an improvement in safety valves for steam boilers, which letters patent are numbered 58294, and bear date the twenty-fifth day of September, in the year one thousand eight hundred and sixty-six; and

Whereas the said Richardson subsequently assigned, sold, and transferred an undivided interest in said patent, or letters
388 patent, to other parties, and the undersigned became part owner, and at this date is the owner in his own right of an undivided fifth part or proportion of the interests of said letters patent, as will appear by the records of the Patent Office—

Now, therefore, to all whom it may concern, be it known that, for and in consideration of the sum of one thousand dollars to me in hand paid, and other valuable consideration, the receipt of which is hereby acknowledged, I, William H. Poor, the undersigned, of the city of Troy, in the county of Rensselaer and State of New York, have sold, assigned, transferred, and set over, and by these presents do sell, assign, transfer, and set over, unto Merritt Clark, of Poultney,

in the county of Rutland and State of Vermont, the undivided fifth part of all the right, title, and interest whatsoever which I have in and to the said invention and in and to the letters patent therefor aforesaid, the said undivided fifth part to be held and enjoyed by the said Clark for his own use and behoof, and for the use and behoof of his legal representatives, to the full end of the term for which said letters patent are or may be granted, as fully and entirely as the same would have been held and enjoyed by me had this assignment and sale not been made.

In testimony whereof, I have hereunto set my hand and affixed my seal, this first day of July, A. D. 1878.

WILLIAM H. POOR. [SEAL.]

In presence of—
CHAS. WING.
W. F. POOR.

Recorded July 18, 1878.

Liber K[23], p. 478.

TROY, *July* 16, 1869.

By terms of agreement between George W. Richardson & Co. and Starbuck Brothers, relating to the manufacture and sale of safety valves of George W. Richardson's patent for and in the State of New York, said contract bearing date January 10, 1868, the percentage allowable and to be allowed for the sale of valves is
389 fixed at twenty per cent., said allowance to date from the date of execution of said contract; the percentage to be allowed agents and others for the sale of valves for and in the State of Ohio is fixed at twenty-five per cent., said allowance to date from the first day of May, 1869.

GEO. W. RICHARDSON.
GEO. H. STARRUCK.

Recorded February 5, 1879.

Liber K[23], p. 479.

For value received, I, George M. Taylor, assignee in bankruptcy of Benjamin Starbuck and George H. Starbuck, hereby sell, assign, transfer and set over to Joseph B. Carr, of Troy, N. Y., all the right, title, and interest of said Benjamin Starbuck and George H. Starbuck, composing the firm of Starbuck Brothers, in and to a certain contract and agreement, bearing date January 10, 1868, and recorded in the Patent Office February 6, 1868, in Liber D[10], page 86, of Transfers of Patents, between G. W. Richardson & Co. and Starbuck Brothers; also in and to a certain other contract and agreement between the same parties, bearing date May 1, 1869, and recorded in the Patent Office July 10, 1869, in Liber X[11], page 333, of Transfers of Patents; also in and to a certain other contract and agreement between said George W. Richardson & Co. and George H. Starbuck, bearing date July 16, 1869, amending the said agreement of January 10, 1868.

In witness whereof, I have hereto set my hand, this tenth day of December, 1878.

GEORGE M. TAYLOR,
Assignee in Bankruptcy.

Witness:
N. DAMIPALE.
SHELDON A. GILLESPIE.

Recorded February 5, 1879.

390 Liber Y[23], p. 105.

Know all men by these presents, that we, George W. Richardson and Sarah M. Gould, of Troy, in the State of New York, Henry Waterman, of Hudson, in said State, and Merritt Clark, of Poultney, in the State of Vermont, being the owners of or being interested in the ownership of the patents hereinafter mentioned and described, in consideration of fifty thousand dollars to us collectively paid by The Consolidated Safety Valve Company, a corporation duly organized under the statute laws of the State of Connecticut, and located at Hartford, in said State, by the issue to us of fifty thousand dollars, par value, of its capital stock, the receipt whereof we do hereby acknowledge, have sold, assigned, transferred, and set over, and by these presents do sell, assign, transfer, and set over, unto the said The Consolidated Safety Valve Company the following-described patents of the United States, and all our right, title, and interest therein, individually and as members of the firm of George W. Richardson & Co., if we are members of said firm, viz: No. 58249, issued to George W. Richardson, September 25, 1866, for steam safety valves; No. 83320, issued to George W. Richardson and Henry Waterman, October 20, 1868, for improvements in steam safety valves; No, 85963, issued to George W. Richardson, January 19, 1869, and the invention secured or intended to be secured by said patents, and all reissues, extensions, and renewals of the same, or either of them, which may be hereafter granted; meaning and intending to convey hereby the right to demand, collect, and receive any and all sums of money which is now due to us, or said firm of George W. Richardson & Co., for royalties, patent fees, and infringements of said patents, or either of them; hereby authorizing said grantee to take any and all proper and necessary steps, by suits or otherwise, to collect, receive, and enjoy all that may be due from users and infringers of said patents, or either of them.

The said patent and inventions, and all the matters herein and hereby assigned and conveyed, to be held and enjoyed by the said
The Consolidated Safety Valve Company, its successors and
391 assigns, as fully and completely, in all respects, as the grantors could have done *have done* had not this assignment been made; and further, the grantors, each for himself only, agree to and with the grantee corporation that if they, invividually or jointly, make any invention or inventions relating to safety valves, that they will assign and convey the same to the said The Consolidated Safety Valve Company and the patents therefor when granted, and that

they will do all proper and necessary acts and things to apply for and obtain patents for such inventions, if any are made, the said corporation paying all costs and expenses thereof.

In witness whereof, we, the said grantors, have hereunto set our hands and seals, this fifteenth day of February, 1879.

GEO. W. RICHARDSON. [SEAL.]
SARAH M. GOULD. [SEAL.]
HENRY WATERMAN. [SEAL.]
M. CLARKE. [SEAL.]

In presence of—
Witness of signatures of G. W. Richardson, Sarah M. Gould, Henry Waterman—
F. W. RICHARDSON.

Witness to signature of M. Clarke—
E. CLARKE.

Recorded February 26, 1879.

Stipulation.

United States Circuit Court, Northern District of Illinois.

THE CONSOLIDATED SAFETY VALVE CO. *v.* ERASTUS B. KUNKLE.

It is hereby stipulated and agreed that the foregoing affidavits and depositions of Forbes, Richardson, Moore, and Hoadley in the above-entitled cause shall be deemed and taken to be originals, and that the pleadings and copies of patents printed herein are accurate and true copies of the originals on file.

Chicago, 5th July, 1882.

THOS WM. CLARKE,
Of Counsel for Comp't.
J. H. RAYMOND,
Of Counsel for Def't.

Endorsed: Filed July 6th, 1882. W. H. Bradley, cl'k.

392 NORTHERN DISTRICT OF ILLINOIS, *ss:*

I, William H. Bradley, clerk of the circuit court of the United States for said northern district of Illinois, do hereby certify the above and foregoing to be a true and correct transcript of the record of all the proceedings had in said court in said entitled cause, wherein The Consolidated Safety Valve Company is the complainant and Erastus B. Kunkle is the defendant, as the same appear from the files and records of said court, now remaining in my custody and control.

In testimony whereof, I have hereunto set my hand and affixed the seal of said court, at my office, in Chicago, in said district, this tenth day of July, A. D, 1883.

[SEAL.] WM. H. BRADLEY, *Clerk.*

Endorsed on cover: N. Illinois C. C. U. S. No. 547. The Consolidated Safety Valve Company, appellant, *vs.* Erastus B. Kunkle. Filed August 16th, 1883.

119-45

United States Supreme Court.

OCTOBER TERM, 1885.

Appeal from Northern District of Illinois.

CONSOLIDATED SAFETY VALVE COMPANY
vs.
ERASTUS B. KUNKLE.
} No. 255.

The appellant and the appellee jointly move that the attached stipulation, with the matters and things therein contained, be made a part of the record herein, and for reason therefor state:

That, by stipulation of the parties before issue joined at circuit, the said matters, being then of record in another case under said patents, were made a part of this record.

That this cause at circuit proceeded thereon; that the record herein was prepared and supervised by one of the counsel herein, and that said matters and things were inadvertently omitted in making up said record.

That thereby no question of jurisdiction is raised, and that whatever the determination of this court thereon may be, the finding of the Circuit Court could not thereby be altered or affected; but if said matters are given any force under the issues, it would be to affirm the finding of the Circuit Court.

THOS. WM. CLARKE, *for Appellant.*

JAMES H. RAYMOND, *for Appellee.*

119-45

No 255

SUPREME COURT OF THE UNITED STATES.

IN EQUITY.

CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

Motion to amend record and

STIPULATION.

THOS: WM: CLARKE,
Solicitor for Appellant.

JAMES H. RAYMOND,
Solicitor for Appellee.

Supreme Court of the United States.

IN EQUITY.

CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

STIPULATION.

It is hereby stipulated and agreed by and between the parties to the above-entitled cause, that, by a stipulation of the parties herein made and entered into before this cause was at issue in the Circuit Court, the record in the case of the *Consolidated Safety Valve Company* v. *The Crosby Steam Gage & Valve Company*, heretofore and now pending in the United States Circuit Court for the District of Massachusetts, and heretofore heard in the Supreme Court, should be considered a part of the record in this cause, and that either party hereto should use and refer to any part or parts of the record in said cause, and that the matters and things hereinafter contained and referred to were so used and referred to in the hearing of this cause in the Circuit Court; and the

parties hereto hereby consent that the record of this cause now pending in the Supreme Court shall be amended by inserting the matters and things hereinafter contained; to wit, —

First. The deposition of Henry Waterman taken in the said suit between the appellant herein and the said Crosby Steam Gage & Valve Company, as follows: —

Boston, October 26, 1880.

DEPOSITION OF HENRY WATERMAN.

Direct Examination by Thos: Wm: Clarke, Esq., *of Counsel for Complainants.*

Int. 1. What is your name, age, residence and occupation?

Ans. Henry Waterman; sixty-five; Hudson, N.Y.; and I am now engaged in the introduction of improvements in the locomotive engine.

Int. 2. Have you been connected with any railroad in charge of the locomotives; if so, what railroads, in what capacity, and when?

Ans. In 1838 I took charge of the machinery of the Hudson & Berkshire Railroad, and remained in that capacity until 1842. In 1851 or 1852, I took charge of the machinery of the Hudson River Railroad. I was there about two years. I took it temporarily, the road being new. I then resigned. Since 1852 I have been almost the entire time engaged in experimenting with machinery. I have been occupied with inventions, and am engaged in that now; mostly appertaining to locomotive engines.

Int. 3. During the time when you were in charge of locomotives on any railroad did you have occasion to consider

the working of the safety-valves of the locomotives; and if so, what did you find to be the defect of the ordinary safety-valve, and did you try to remedy it, and with what result?

[*Objected to as immaterial and incompetent.*]

Ans. During the first year I had charge of the Hudson River Railroad my attention was called to the Bourdon steam gauge, being the first steam gauge outside of the old mercury gauge I ever saw. We were using the old ordinary safety-valve with the lever and spring, and I found we had been very much deceived as to the true pressure of the steam; that the steam would rise to a very high figure above the blowing point. In one case I had set a valve to blow at one hundred and thirty, as I supposed — the steam had risen to one hundred and seventy. I at once set about finding a remedy for it. My first thought was a weight applied to the lever, which would give a constant load upon the valve. I knew that the undulations and bouncings of the engine would act unsteadily, so I passed the rod that held my weight down into a cylinder, upon which I put a piston, and filled the cylinder with oil. This entirely prevented the bouncing affecting the weight, and it worked very satisfactory to me. It had only this defect: the steam would rise about five or six pounds above the blowing point; but that I did not care for, as I had already submitted to such immense margins of pressure I did not feel afraid. I had one of these valves upon a locomotive named "Lowell," set at one hundred and twenty pounds pressure, and during one of her trips she blew open one of her side seams in the waist of her boiler. I had no spare engines, and I thought I could use her with a low pressure of steam upon a construction train, provided I could make a valve in which the steam would not rise above a certain point at which it was set to blow, and I constructed a valve with a supplemental area on

the top of the valve, and put it upon the "Lowell" with a lever, weight and oil dash-pot. The first time we fired up the "Lowell" after this valve was put on her, very suddenly the valve opened and produced a great panic among the workmen in the shop. I went at once into the cab and found steam and water escaping from the safety-valve, and I took hold of the lever and pulled the valve down. I instructed the engineer to watch it closely and not allow it to escape freely, and to pull it down whenever he thought proper. I had attained the object I set out to accomplish. It kept the steam strictly within the blowing point. It would blow the steam down considerably, but I did not care for that on this engine.

Int. 4. Did you ever, before the year 1866, find any safety-valve capable of preserving the working pressure in a boiler, of keeping the pressure at the working pressure and not allowing it to rise above it, and of relieving the boiler from excess of pressure with but small loss of pressure; and if so, when and where did you encounter such a valve?

[*Objected to, it being immaterial what the witness failed to discover.*]

Ans. I never saw or encountered such a valve previous to 1866. My valve let the steam down about fifteen pounds, which would not be practical for an ordinary locomotive; besides, it would have to be watched very closely or it would blow the water out of the boiler.

Int. 5. Would a valve of the description inquired of in the last interrogatory have been a desirable safety-valve for introduction into the market, and would it have been likely to have reached a considerable sale?

[*Objected to as incompetent so far as it calls for opinion.*]

Ans. During my early experiments we were burning wood in our locomotives; the strength of the fire would

immediately die out in shutting off the blast. In the meantime coal had been introduced generally as fuel on locomotives. The coal fire, when blown into great intensity, will go on and throw out large volumes of heat after the blast is off. It would have what I should call momentum, and steam would rise rapidly. In the anthracite engine there was a supplemental lever upon the safety-valves, and the engineer was instructed to change the pressure to prevent an accumulation under the valve to an undue point. After the introduction of coal the locomotive boiler explosions were reported frequently; every railroad in the country I knew of was suffering disasters of that kind. Such a valve as inquired of was thought at that time to be very desirable, and when such a valve was shown, it was adopted with remarkable rapidity.

Int. 6. When was such a valve first introduced, and whose manufacture was it?

Ans. In the year 1866 such a valve was introduced by Mr. George William Richardson.

Int. 7. Whether or not that valve went into use; and if so, how rapidly and to what extent?

Ans. I think I never saw a new contrivance in my life so readily adopted, and that went into such general use. I think it safe to say that almost all the coal-burning roads adopted it at once. The Baltimore & Ohio was the last great road that adopted it; and after they had tried one, they ordered this valve for all their locomotives at once.

Int. 8. Whether or not the Richardson valve has held the market with railroads since 1866?

Ans. It held the market without a competitor for a great many years, and I think it safe to say that it holds the market to-day.

Cross Examination by WILLIAM A. HERRICK, Esq., *of Counsel for Defendants.*

Cross-Int. 9. Are you a stockholder in the plaintiff corporation; and if so, to what extent?

Ans. I am a stockholder, and own about one eighth of the stock.

Cross-Int. 10. Did you take out a patent for the valve which you say you invented, and described in your direct examination; and if so, when and where?

Ans. I did, in 1853, in the United States.

Cross-Int. 11. Did you ever claim that your invention, as secured by those Letters Patent, anticipated the invention of Mr. Richardson to which you have referred as patented in 1866?

Ans. I believe I have claimed that, as far as relieving the boiler was concerned, I did anticipate it.

Cross-Int. 12. What feature in the construction of your valve did you claim anticipated the Richardson valve?

Ans. In the supplemental surface and action of the steam upon it to assist its rising.

Cross-Int. 13. Did you become a partner with Mr. Richardson in the manufacture and sale of valves; and if so, when?

Ans. I became his partner in 1866 or 1867.

Cross-Int. 14. What was the style of the firm, and how long did you remain a partner with him in the manufacture and sale of valves?

Ans. G. W. Richardson & Co. was the name of the firm which is undissolved to-day.

Cross-Int. 15. Did you convey to G. W. Richardson & Co. your patent obtained for your valve?

[*Objected to as immaterial and incompetent.*]

Ans. My first patent was only for the weight and dash-pot. I made no mention of the valve itself except in the drawing. By my terms of conveyance I was to let them have my patent and obtain a reissue for the valve. I did obtain a reissue for the valve and conveyed it to them.

Cross-Int. 16. Was that reissued patent conveyed to the plaintiff corporation?

Ans. It was not.

Cross-Int. 17. Why not?

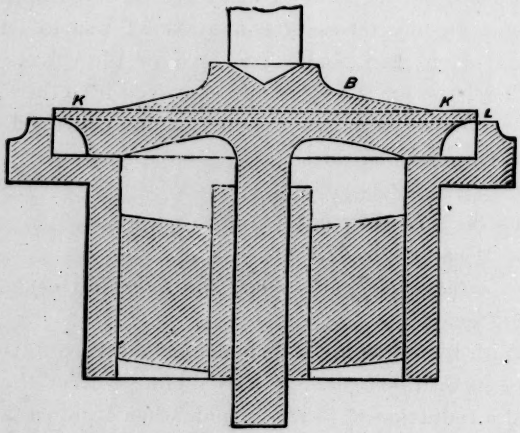
Ans. It had expired.

[*The witness wishes to make the following explanations and additions:*]

1. With regard to my statement that my valve blew down the pressure fifteen pounds, I wish to say that the gauge showed a reduction of fifteen pounds when I pulled the valve down; how much below that it would have gone I do not know.

2. And with regard to my answer to cross-interrogatory 11, I wish to say that I thought the question related to any time previous to 1866. In my reissued patent of July 9, 1867, I described the action of my valve as it then stood, as doing all that Richardson claimed for his valve, and as a result of experiments made with my valve after Richardson had introduced his valve.

Cross-Int. 18. Will you please look at the drawing now shown you, and state whether that represents the valve secured by your reissued Letters Patent?



Ans. To the best of my recollection it is a fair representation of it. I do not know that it shows the proportions as I drew them. I drew the proportions carelessly, without any reference to making them exactly as I made my valve. I took out my patent for another party who wanted it; both he and myself cared only for the weight and the dash-pot, so I had no intention of giving my valve an exact representation.

Cross-Int. 19. Do you refer in your last remark to your original Letters Patent, or to the reissue?

Ans. I referred to my original patent.

Cross-Int. 20. Will you please produce and annex to your deposition a copy of your specification and claims of your reissued patent?

[*Objected to as immaterial.*]

Ans. I produce a copy thereof, as follows: —

UNITED STATES PATENT OFFICE.

LETTERS PATENT No. 10,243, DATED NOVEMBER 15, 1853; REISSUE No. 2675, DATED JULY 9, 1867.

GRANTED HENRY WATERMAN, OF HUDSON, N.Y.

IMPROVEMENT IN SAFETY VALVES

The schedule referred to in these Letters Patent and making part of the same.

To all whom it may concern:

Be it known that I, Henry Waterman, of Hudson in the County of Columbia in the State of New York, have invented a new and useful improvement on the safety-valve for steam generators; and I do hereby declare that the following is a full, clear and exact description of the construction and operation of the same, reference being had to the annexed drawings making a part of this specification, in which —

A represents a vertical section of part of the boiler.

B represents a vertical section of the valve.

C, the ordinary lever.

D, the weight.

E, the rod upon which the weight is suspended.

F, the piston attached to the rod E.

G, the cylinder in which the piston F moves freely.

H is a stand by means of which the cylinder is attached to the boiler or other permanent support.

I I I I represent the fluid in the cylinder G which covers the piston F.

k k represent the overhanging part of the valve, which increases its area outside of and beyond the ground-joint. *l l* represent a concentric rim or ledge that directs the steam

upwards against the overhanging part *k k*, by means of which the valve is assisted in rising.

In the ordinary safety-valve of steam generators it has long been known that there existed a strong inclination or attraction between the valve and the seat other than that produced by the superincumbent weight or force; or, in other words, when the valve is loaded so that steam shall commence to escape from the generator at a given density or pressure of the steam, it requires a greatly increased force against the valve to raise it to a distance from the seat that will allow any near approach to the full capacity of the valve for effecting the escape of steam. This is true when the superincumbent force is constant, as in the case when a weight is used; it is still more forcibly felt when the superincumbent force is a spring, as is the case in all locomotive engines, for the reason that the force of the spring increases as it is moved. I construct the safety-valve of steam generators so that the aforementioned disposition shall be counteracted and its evil effects entirely prevented. I desire to use a weight, whenever it is possible, for the reason that the force due to its gravity is constant. The weight is generally used with the generators of stationary and steamboat engines. In the case of locomotive engines, however, their jolting, when in motion, causes the valve (when a weight is used) to jump up from its seat before the steam has attained sufficient density or pressure to raise it. To counteract this jolting, jumping tendency, I attach to the weight a piston working in a liquid dash-pot. This will only prevent the jolting tendency, however. Another contrivance is necessary to counteract the disposition of the valve to stick or be attracted to the seat. For this purpose I construct the valve and seat so that the escaping steam shall act upon an increased area of the valve after it has raised from its seat; or,

in other words, so that, when the valve has raised from its seat, the escaping steam is so directed that its force strikes an overhanging or projecting annular surface on the top of the valve and outside of and beyond the ground-joint. Thus in the drawing *k k* indicates this overhanging or projecting annular surface, while *l l* indicates a concentric rim or ledge so constructed as to turn the force of the escaping steam against *k k*. This force may be modified by a proper modification of the overhanging or projecting annular surface; thus, if the overhanging surface be large, the force of the steam will suddenly open the valve, and discharge so much steam that the pressure in the generator will be considerably reduced before the valve closes. This overhanging surface *k k* may, however, be made so small that but little more than the surplus steam actually generated will escape. In either case, besides overcoming the sticking or attraction of the valve to the seat, this most desirable object will be attained, to wit, the steam pressure in the generator will not rise a particle above the initial point of escaping. The peculiarity of this form of valve is this: that while it prevents the steam from rising above the initial point of blowing, the valve will remain open until the pressure is reduced below the initial point of blowing before it will be allowed to close. The success or efficiency of it must depend upon a proper proportion of the parts *k k* and *l l*; thus, if those parts are of large proportion, and the steam allowed a free discharge between them, it will not at all assist the valve in rising. Again, if they are made too large, and the escape between them be too small, it will cause the valve to rise too easily and remain open too long, so that the steam will be so much reduced in pressure as seriously to impair their economical and efficient condition. It has been found in practice, for instance, that in case of a safety-valve, such as

is usually used in the locomotive engines, of about two and a half inches in diameter, with a pressure of steam about one hundred and thirty pounds per square inch, if the overhanging part *k k* is made of a diameter of about one sixth of an inch on each side, larger than the valve proper, and the ledge or rim *l l* is made of a diameter about one sixteenth on each side, larger than *k k*, so as to leave an opening of about one sixteenth of an inch in space between the parts *k k* and *l l*, and the part *k k* is made to sink down into the cavity formed by the parts *l l* about one sixteenth of an inch, the valve will rise and will discharge the steam freely until the pressure is reduced about three pounds per inch below the initial point of blowing, which I consider a most desirable and efficient operation; these being the proportions when the pressure is used of different density until a small margin of difference is obtained between the opening point of pressure and the closing. Thus it will be seen that when it is ascertained that the generator has sufficient strength to bear with perfect safety a given load or pressure, the use of this valve will not allow the pressure to exceed that point when the valve has been gauged to said point. Boiler explosions, caused by excessive pressure, will, therefore, be entirely prevented, and boiler leakage, caused by great variations of pressure and temperature, will also be prevented.

The operation of this contrivance is as follows: As before stated, I prefer, in order to attain a most perfect action, to use as a superincumbent force a weight which will put upon the valve a steady, uniform force, which will not increase as it is raised; and to counteract any jolting tendency, I use the piston F, working in the cylinder G, immersed in the I I I I. It is evident that the piston cannot move in the cylinder without requiring the fluid to pass from one side of the piston to the other. I make the piston

sufficiently small, so that it will not only move without touching the sides of the cylinder, but will allow the fluid to pass slowly, yet freely. Thus it will be seen that the piston will move slowly to its proper position, avoiding any sudden motion caused by jar or jolting. Then when the steam has been raised to a point that, by its pressure upon the lower side of that portion of the valve within the area of the opening through the seat, it is enabled to raise the superincumbent weight, it will allow the steam to escape. This escaping steam is then, by the concentric rim or ledge *l l*, directed upward against the enlarged area of the valve, made by the overhanging part *k k*, the comparative size of which must be such, and the size of the orifice made by the approach of the parts *k*, *k* and the parts *l*, *l* must also be such, as to form a sufficient retardment of the escaping steam, or just sufficiently to raise the valve and counteract the sticking tendency of the valve before mentioned; for, as before mentioned, when the valve is assisted too much by the improper proportion of these parts, the valve will stay open too long, the steam will escape until it will be too much reduced in pressure. This action will defeat the object I have in view, which is to keep the pressure of the steam as near as possible the initial point of blowing, and not allow it to go above that point, and not to escape materially below it.

What I claim as my invention and desire to secure by Letters Patent is —

1. The piston F, attached to the weighted end of the valve lever, within the cylinder G, and immersed in the liquid in the cylinder, combined and operating in the manner and for the purpose herein described.

2. I also claim the concentric rim or ledge *l l* and the overhanging part of valve *k k*, constructed, combined and

operating in the manner and for the purpose herein set forth.

HENRY WATERMAN.

Witnesses:

GEO. W. RICHARDSON,
W. H. POOR.

Cross-Int. 21. Do not the letters K K and L, in the drawing contained in cross-interrogatory 18, correspond to the letters *k k* and *l*, in the specifications introduced into your last answer?

Ans. They do.

Cross-Int. 22. Did you not inform Mr. Richardson before going into company with him that if he manufactured valves under his patent of 1866 he would infringe your invention of 1853?

[*Objected to as incompetent and immaterial.*]

Ans. I did not; nothing of the kind. The first I ever saw of Mr. Richardson, he came to Hudson and called on me, and remarked very cautiously that he had heard I had a patent for a safety-valve. He seemed to be hesitating considerably about introducing his subject, and I said to him just this, "I know what you have come for; let me do the talking." I went to a trunk and pulled out my old parchment of a patent, that had not seen the light for thirteen years. I pointed to my valve as shown in the patent drawing and said, "I can make that valve do just what yours does." I said this because I had experiments made at Greenbush with it. "It is folly," I said, "for us to quarrel. I can't make my valve because I never used a spring upon it, and only can use it in connection with a weight; and if I reissue my patent you can't make your valve until the expiration of my patent. So there will be a dead-lock here for a little over seven years." I then proposed to him that

I would pay one half of all their expenses if they would give me a one-third interest in a company combining the patents of Richardson and Waterman. A contract to this effect was signed the next day.

Cross-Int. 23. What did you understand to be the feature distinguishing Richardson's patent of 1866 from your reissued patent?

Ans. I considered it mainly in the use of the spring, and in the fact that my original valve relieved the boiler the same as his.

Cross-Int. 24. Were G. W. Richardson & Co. interested in the suit in the Circuit Court of the United States, District of Massachusetts, entitled *George W. Richardson* v. *Edward H. Ashcroft?*

[*Objected to as immaterial and incompetent.*]

Ans. They were.

Cross-Int. 25. Were you familiar with the proceedings in that suit?

[*Objected to for same reasons.*]

Ans. I don't think I was. I never was present but once during the taking of testimony. I read only a small portion of the testimony.

Cross-Int. 26. Who was the witness testifying when you were present?

[*Objected to for same reasons.*]

Ans. It was the first witness, — Mr. Hill.

BOSTON, October 27, 1880.

Direct Examination resumed.

Int. 27. When you tried your experiments with your valve, was it after you had heard of the Richardson valve and its work and success, and did you make your experimental valves like your original valve on the "Lowell;" and

if not, what changes did you make in them, and how did you proceed?

Ans. It was after I heard of the success of the Richardson valve. I did not make them like the original valve on the "Lowell." My original valve had more supplemental surface than my experimental valve, larger proportion of supplemental surface. It had practically no opening or stricture, and was as tight as I could make it to work without friction. I procured a Richardson valve, — it had his name on it, — and conformed as near as I could in my experimental valve to the proportions of parts of the Richardson valve and their relations to each other. My experimental valve generally conformed in form to my original valve. After several trials with the experimental valve, mostly in enlarging the capacity of the stricture, I succeeded in making it open promptly, and relieve the boiler, and close with a loss of about three pounds pressure per square inch.

Int. 28. Did you load these experimental valves with a spring or weight?

Ans. I used a direct-acting spring like Richardson's.

Cross Examination resumed.

Cross-Int. 29. When were the experiments referred to in your answer to interrogatory 18 made, and where?

Ans. Somewhere about midsummer, 1867, in Greenbush. That is my best recollection of it.

Cross-Int. 30. Who was the George W. Richardson who witnessed your signature to the specification and claims in your reissued patent?

Ans. The inventor of the Richardson valve.

Cross-Int. 31. Was the application for the reissued Letters Patent made after you went into company with George W. Richardson?

Ans. It was.

Cross-Int. 32. Was Mr. Richardson aware of the application?

[*Objected to as immaterial and incompetent.*]

Ans. He was.

Cross-Int. 33. Did he examine your specification and claim for your reissued patent?

[*Objected to.*]

Ans. I don't know whether he did. I am rather inclined to think he did not.

Cross-Int. 34. But it was agreed, was it not, between you and him, that you should take out this reissued patent, which you did?

[*Objected to as immaterial.*]

Ans. No, it was not. It was agreed that I should apply for it.

[*Complainants offer in evidence certified copy of United States Letters Patent to Henry Waterman, No.* 10,243, *dated November* 15, 1853, *and the same is marked "Complainants' Exhibit Waterman Patent, G.S., Examiner."*]

HENRY WATERMAN.

Attest: GEO. SHEFFIELD, *Special Examiner.*

COMPLAINANTS' EXHIBIT WATERMAN PATENT.—G. S., Exr.

LETTERS PATENT OF THE UNITED STATES No. 10,243.

GRANTED HENRY WATERMAN, NOV. 15, 1853.

STEAM SAFETY VALVE.

SPECIFICATION.

To all whom it may concern:

Be it known that I, Henry Waterman, of the city of Hudson, County of Columbia, State of New York, have invented a new and improved mode of constructing the safety-valves of locomotive engines; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings and letters of reference marked thereon.

Owing to the jolting of the locomotive engine when in motion, it was found necessary, at an early day, to discard the use of the simple weight upon the lever of the safety-valves, as large portions of steam would be blown off when the pressure was below the point indicated by the mean pressure of the weight upon the valve; as, for instance, when the boiler was suddenly thrown upward the weight would continue to go up, so that by the recoil and momentum the valve would be a portion of the time raised from its seat, and the steam allowed to blow off when below the desired point of pressure. The spring balance was substituted and has been generally used or applied to the lever of safety-valves.

It has been long known that the spring balance is an im-

perfect indication of the pressure of steam, from the following causes: —

The safety-valve in raising will raise the outer end of lever that rests upon, though a much greater distance than the valve itself as the proportions of power of the lever, as, for instance, a lever of a power of twelve times, resting on a valve, say two inches diameter, when the valve is raised to its full capacity, say one half inch, will raise its outer end six inches, a distance quite impossible with an ordinary spring balance, without greatly increasing the pressure balance, consequently at the same time increasing the pressure of the steam, so that it will be seen an adequate discharge cannot take place with a spring balance resting upon; taking another instance, suppose a valve to raise one eighth of an inch, which allows an escape of about one fourth the capacity of the valve, the outer end of lever will raise one and a half inch; if to this a spring balance is attached with a scale of one twentieth of an inch to the pound, it is evident that the pressure will be increased thereby thirty pounds per inch. To remedy this difficulty, I propose to use the simple weight and lever so as to attain as near as possible a constant and uniform pressure upon the valve; and in order to prevent the vibrations of the weight and lever, I apply to outer end of lever a rod that descends vertical, by which the weight is suspended to lever at the bottom of said rod. Below the weight attach a small piston of about three inches diameter. Surrounding this piston I place a cylinder in which this piston is allowed to move freely and easily; the cylinder is firmly attached to boiler or other convenient parts; into this cylinder I put a fluid, — mercury, oil, alcohol or water. I prefer good sperm oil. This fluid must fill the cylinder to near the top so as to completely cover the piston. It is evident that the piston can move no faster than the fluid is

made to pass by the piston, and that it will check all sudden vibrations, yet freely pass to a position due to pressure, &c. By having an adequate facility of discharging surplus steam, we have succeeded in securing a uniform temperature and pressure in the locomotive boiler, preventing almost entirely the difficulty of leakage of tubes, riveted joints, so commonly caused by these variations; also design it as a sure preventive of explosion from these causes.

DESCRIPTION OF DRAWING.

A represents the rear part of boiler.

B represents the ordinary safety-valve.

C represents the ordinary lever.

D represents the weight.

E represents the rod upon which the weight is suspended to lever.

F represents the piston attached to rod E.

G represents the cylinder, in which the piston F is allowed to move freely.

H is a stand by means of which the cylinder is attached to boiler A.

I I I I represents the fluid in cylinder G, which covers the piston F.

What I claim as my improvement, and desire to secure by Letters Patent, is the piston F, attached to the weighted end of the valve lever within the cylinder G and immersed in the liquid in the cylinder, combined and operating in the manner and for the purposes herein described.

HENRY WATERMAN.

Witnesses:

DARIUS PECK,

JAMES CLARK.

Second. That the following is a true, full and correct copy of the drawings of the reissue of the said Letters Patent so issued as aforesaid to the said Henry Waterman, July 9, 1867.

Third. That the following facts were and are admitted by the appellant and appellee and stipulated into this record; to wit, —

First, that the said Waterman had talked with the partners of the said George W. Richardson with a view to entering the partnership prior to the first interview had between the said Waterman and the said Richardson, as testified to by the said Waterman; and said partners Gould and Poor had favored the admission of Waterman as a partner, and Richardson had not favored it. Second, that the said George W. Richardson & Co. never made a valve in accordance with the specifications and drawings of either the said original, reissued or extended Waterman patent. Third, that the said firm never marked a valve made and sold by it with the number or date of the said Waterman patent. Fourth, that the said firm never made any threat to bring suit and never did bring any suit against any one under the said Waterman patent, and in the licenses and assignment granted by said firm under said Richardson patent, did not uniformly but did once refer to the said Waterman patent. Fifth, that after the said Waterman was admitted to said firm, the said Waterman patent was reissued,

and was extended and assigned to said firm, but no member or employee of said firm signed or executed any of the memorials or affidavits or other papers upon which the said extension of the said Waterman patent was granted, but the said reissue and extension was assigned to the said firm so as aforesaid.

Fourth. It is further stipulated that the answer of the defendant and appellee herein shall be amended by inserting, after the ninth paragraph thereof and as nine and one half, the following; to wit,—

This defendant further answering, says that, to wit, in the year 1867, the said Waterman patent so granted to Henry Waterman, November 15, 1853, was reissued by the said Waterman for the benefit of the said George W. Richardson and others then associated with him in business, and that the same Richardson participated with him in procuring the same by signing the specifications thereof as a subscribing witness; and that the said reissue so granted as aforesaid is for the same invention as is described and claimed in the said Richardson patent No. 58,294, or the substantial and material parts thereof; and that thereupon and thereby, the said acts of said Richardson amounted to an abandonment of the invention so purporting to be described and claimed in the said patent No. 58,294, and did thereby admit and publish that he, the said Richardson, was not the true and original inventor thereof, but that the said Henry Waterman was; wherefore the said Richardson and those claiming by, through and under him should be, and in equity are, estopped from asserting that said Richardson was the inventor of or

entitled to any benefit under the claim of the said Letters Patent No. 58,294.

Solicitor for Appellant.

JAMES H. RAYMOND,

September 30, 1885. *Solicitor for Appellee.*

119-45

Supreme Court of the United States.

OCTOBER TERM, 1885.

APPEAL FROM NORTHERN DISTRICT OF ILLINOIS.

No. 255.

CONSOLIDATED SAFETY VALVE COMPANY

v.

ERASTUS B. KUNKLE.

MOTION TO ADVANCE.

Appellants state —

1. That the cause is an injunction bill in which they were complainants on two patents for safety-valves, one granted September 25, 1866, — already expired, — the other granted January 19, 1869, which will expire January 19, 1886.

2. That these two patents have been construed by this Court, with all the documentary evidence of anticipation on the present record before this Court, in the case of the present complainants and appellants against the Crosby Steam Gage & Valve Company, Nos. 126, 127, at the last term.

3. That the issues of the present case are, whether

the construction given to the patents by this Court shall be maintained, and whether defendant has infringed according to that construction.

4. That the cause probably cannot be reached in its order before the expiration of the complainant's patents.

5. That on a new injunction bill and motion, filed in Indiana, where defendant resides, after the decision of the said Crosby case by this Court, based on a sale made after said decision, the Court below held, in May last, that the opinion of the Court in Illinois in this cause was binding, as *res adjudicata*, in a suit on a similar subject matter between these parties, and declined to re-examine the question of infringement on the construction given to the patents by this Court; and appellants and complainants have hence failed to obtain preventive relief against the defendant, and are likely to fail unless the cause be advanced.

Wherefore appellants move that the cause may be advanced and heard at as early a day as practical.

THOS: WM: CLARKE,
of Counsel.

To J. H. RAYMOND, Esq., *of Counsel for* E. B. KUNKLE:

Please take notice that on Monday, October 19, 1885, on the coming in of the Court, or as soon thereafter as the case can be heard, I shall move the Court as set forth in the foregoing motion.

Very respectfully,

THOS: WM: CLARKE.

Service of above motion admitted.

operation, which would support a decree finding infringement, was given.

Complainants' expert, without any proof, gives the opinion, that this exhibit infringes, and defendant's expert gives the opinion that it does not. As to this particular exhibit the case is not made. The experiments and theories advanced in complainants' brief at page 38, printed as if relating to this exhibit, in fact refer to complainants' exhibit B. and to "other safety valves *more or less modified* from his (Kunkle's) usual practice for the purpose of experiment." (See record, bottom of page 130 and top of page 131.)

A large number of experiments were tried with and considerable testimony was offered, both by plaintiff and by defendant, concerning complainants' Exhibits B and C. They are, however, for the purposes of any proper discussion identical valves. Complainants' expert finds three differences between them. As to two, he says they "in no way change the operation of the valve" (p. 83). Thethird difference, he says, "is that the flange, *h*, upon the valve, which forms a part of the valve and rises with it, in B does and in C does not fit closely the flange, *f*, which depends from the cap or casing of the valve inside of which depending flange the flange of the valve rises (p. 83). Now, that there should be here sufficient looseness to permit the escape of air when the valve rises is not only, and of course, a necessity, but this escape of air is, as we shall show, of importance in the operation of the Kunkle valve. That this flange fits a little more closely in Exhibit B than in Exhibit C, Mr. Forbes

considers "to be an accident of manufacture," and he finds that Exhibit C "is made substantially like, *in all ma-* "*terial respects*, to the valve shown in Complainants' Ex- "hibit Drawing Kunkle B, * * * and it is "*varied in construction simply* in three respects as above" (p. 83).

Plaintiffs' case therefore is confined to sustaining the patents sued upon and to maintaining infringement by valves of the construction and operation of Complainant's Exhibit C to which exhibit, on the question of infringement, the discussion and this brief will be confined.

THE ISSUES

therefore are:

First. Is either or are both of said Richardson patents valid?

Second. Under a proper legal construction thereof are they or is either of them infringed by defendant's valve Complainants Exhibit C?

THE CONTENTIONS OF APPELLEE ARE:

First. That said patent of 1886 is invalid for want of novelty, being anticipated in each and every part of its specifications by the prior patents to Hartley, Ritchie, Webster and Waterman, and by the prior publication in the Artisan; and being anticipated as to the subject matter *claimed* by said patent to Webster.

Second. That upon any and every construction heretofore or now contended for or possible to be con-

tended for, said patent of 1886 is not infringed by defendant's valve.

Third. That said Richardson in 1867 by his participation in the re-issue of the Waterman patent of 1853, said re-issue being for the invention described and claimed in said patent of 1866, abandoned as an inventor his claim of 1866, and that he and his privies are estopped from claiming under said patent of 1866.

Fourth. That said patent of 1869 is invalid, for that it does not point out, and specifically claim the part improvement or combination sought to be covered thereby.

Fifth. That said patent of 1869 (1) purports to be a patent upon a special and precise combination; and (2) if given any broader construction is anticipated by said Webster patent, and

Sixth. That upon either or any possible construction it is not infringed by defendant's valve.

BRIEF.

PLAINTIFF'S PATENT OF 1866, No. 58,294.

The claim of this patent is:

"*A safety valve with the circular or annular flange "or lips cc, constructed in the manner or substantially in "the manner shown so as to operate as and for the pur- "pose herein described.*"

The first question for this court to determine, in the light of the new facts developed in this case, is:

What are the ordinarily intelligent mechanics and manufacturers of steam engines to fairly under-understand by this language so as that they may do their business honestly, without invading even the face of this claim?

The words of this claim "constructed in the manner" and "so as to operate" can not be made to refer to the valve as a whole without violating all rules of construction. The size, construction, variation, purpose and operation of *the circular or annular flange or lip cc*, is the burden of the specifications and as applied to a safety valve is the subject matter of this claim. It is that flange or lip which is to be constructed to operate as described in the specifications. If this were a claim upon a general construction of a valve having certain elements named in the specifications as essential to the invention and essential to be constructed so as to operate in a particular manner, then it would have been perfectly easy to have said so, and, without attempting to deceive the public, by changing the juxtaposition of the language or by claiming "A safety valve with the circular or annular flange "or lip cc, *which valve is* [or, "all"] constructed and "arranged," etc.

"The annular flange or lip cc," is, in the construction and application named, the first, last and only, or, to use a comparatively recent but very apt expression of this Court, is "the substantive element" of this claim from which all questions of legal construction must emanate.

During the fifteen years that this patent has been in the Courts and has been held *in terrorem* over our

whole people as preventing, without tribute, the safe use of steam boilers, during which time no recorded opinion of the Circuit Court has been rendered in its favor, astute experts have experimented with this patent, have found first this, then that, then the other new *functional* operation *in their experiments*, and have pressed such functions and results upon the Courts as being the subject matter of the claim. Their theories have diametrically differed at different times, and none of them yet advanced have had aught to do with an equitable construction of this claim. Indeed, in this case, at Circuit, as the exigencies of the progress of this cause and the exigincies of announcements made in this and in other courts seemed to require, three different theories as to the proper construction of the simple claim named above have been advanced by complainant's counsel and expert, as we will show later, in considering the question of infringement.

Among others the following thirteen elements have been found in this patent and have been experimented with and learnedly testified about: 1, the initial area of the valve or the surface which is presented to the boiler steam when the valve is seated; 2, the laterally extended head of the valve; 3, the chamber, called "the huddling chamber," under this extension; 4, the area, and 5, the cubic contents of this chamber; 6, the pendant flange or lip cc; 7, the distance between the inner surface of this lip and the outer face of the extended valve around which it "loosely fits;" 8, the distance which this lip overlaps the extended valve seat ~~where~~ Where the valve is seated; 9, the ground joint

or valve seat proper; 10, the extended surface of this valve seat and its superficial area; 11, "the spring or scales" (p. 64), meaning a lever and weight like the old-fashioned "steel-yards," or a direct weight, or a helical spring, located above or below the valve to hold it upon its seat against any pre-determined boiler pressure; 12, a mathematical proportion between the valve proper and its supplemental area; 13, mathematical relations between the strength or compression of the spring and the size of other parts.

The specifications, as should always be the case, contains a statement of the inventor's object or purpose, and of the means by which he attains the same, as follows (p. 64):

He states *the means* which he desires to patent as follows:

"The nature of MY INVENTION CONSISTS *in increas-*
"*ing the area of the common safety valve outside of its*
"*ground joint and terminating it in such a way* as to form
"an increased resisting surface against which the steam
"escaping from the generator shall act with additional
"force after it has lifted the valve from its seat at the
"ground joint."

He states *the object* to be attained, as follows:

"And so by overcoming the rapidly increasing resist-
"ance of the spring or scales, insure the lifting of the
"valve still higher, thus affording so certain and free a
"passage for the steam to escape as effectually *to prevent*
"*the bursting of the boiler or generator even when the*
"*steam is shut off and the damper left open.*"

Mr. Forbes, complainant's expert, agrees with us in saying that in addition to the foregoing, the following, now italicized, comprises "fully and fairly all the language "of the Richardson patent of 1866, which tends to "enlighten us as to the nature and purpose of the inven- "tion claimed therein." (p 101).

[NOTE: We beg the Court to notice whether in the preceding or the following quotations there is one single suggestion to those ordinarily skilled in this art as to the amount of steam remaining in the boiler when the valve closes.]

"This increased area may be made by adding to a "safety valve already in use, or by casting the whole "entire. *I terminate this addition to the head of the valve "with a circular or annular flange or lip cc, which pro- "jects beyond the valve seat EE, Fig. 3, and extends "slightly below its outer edge and fitting loosely around it and "forming the circular or annular chamber DD, whose trans- "verse section, shown in the figure, may be of any desir- "able form or size. The flange or lips cc, fitting loosely "around the valve seat EE, is separated from it by "about one sixty-fourth of an inch for an ordinary spring "or balance. For a strong spring or balance this space "may be diminished, and for a weak spring or balance it "should be increased to regulate* THE ESCAPE *of the steam "as required.* * * * With my improved safety "valve constructed as now described * * the "steam * * acts against the increased surface "of the valve head, and by this means, together with its "reaction * * it overcomes the rapidly increas-

"ing resistance of the spring or balance, lifts the valve "still higher and *escapes freely into the open air until the* "*pressure in the generator is reduced to the degree desired,* "*when the valve will be immediately closed by the tension* "*of the spring or balance.* The ESCAPE OF THE STEAM "by means of this safety valve is so certain and free that "the pressure of the steam in the generator or boiler will "*not increase beyond the point or degree at which the valve* "*is set to blow off.*"

In the Richardson patent of 1869, we meet his first suggestion (after several years of experimenting with his patent of 1866) as to the amount of steam remaining in the boiler when the valve shall have closed; but our present reference to this latter patent is for the purpose of getting his own solemn statement as to what he sought to cover by his patent of 1866.

The patent of 1869, in terms "relates to improve- "ment in the invention described in letters patent granted "to me and bearing date the 25th day of September, "1866." Therein Richardson says that "said patented "invention" (i. e., his patent of 1866), "relates to a *means* "for providing a *more free escape for the steam* than "could be obtained by safety valves as constructed prior "thereto, and to *insure the keeping of the valve open* "until the pressure of the steam in the boiler or generator "*falls below* the pressure which was required to open it: "the *said means* so patented, consisting in forming the "valve with a *surface outside of the ground-joint for the* "*escaping steam to act against, the said surface being sur-* "*rounded by a projecting or overlapping lip, rim or flange,*

"*leaving a narrow space for the escape of the steam when* "*the valve is open:* but which, although of greater diam- "eter than the valve seat, by reason of the said lap, "presents a less area of opening for the escape of steam "than is produced at the valve seat, so that the steam "which escapes through the area between the valve shall "exert pressure against the said surrounding surface, "and thereby not only open the valve completely, but hold "it up until the pressure of the steam in the boiler "falls BELOW *the pressure by which the valve was opened.*"

Now, any manufacturer or mechanic, no matter how skilled in the art—the public, for whom these specifications were written, on a very careful reading and study of them, and of this claim, would conclude that the inventor's *object* was simply that the steam should "escape freely into the open air, and reduce the steam in the boiler below (not at) the pressure by which the valve was opened;" and that *the means* which he attempted to patent for that purpose consisted in extending the valve head (as shown outside the lines p, p, Fig. 4, p. 64) and terminating it in the pendant, loosely fitting flange or lip *cc*, which laps over the valve seat and is separated therefrom in the neighborhood of one sixty-fourth of an inch for the different kinds of springs which may be used—this means and its then well-known mechanical equivalents, if any, being the subject matter and the scope of the claim.

To be sure, he says, this means will allow of such free escape of steam until "the pressure in the generator

is reduced *to the degree desired* when the valve will be *immediately* closed by the tension of the spring or balance."

If it be asked whether in this and his other specications he has not described means for relieving the boiler of all excessive and dangerous steam while still retaining a working pressure of steam in the boiler, and, being the first to describe and claim such means, he is entitled to a broad construction for his patent as a foundation or "mother patent." The answers are:

First. A fair consideration of the face of the paper when read from the standpoint of what is intelligible and plain to those skilled in this art, tells us that "the degree desired" is simply the degree of safety desired. The context of the words italicised in the second paragraph above require this construction.

Second. Richardson testifies (p. 80) that until after he had introduced his (a) valve on locomotives (he was a locomotive runner and repairer. p. 79) he knew nothing about the prior patents to Naylor, Beyer, Hartley, Green, Ritchie and Webster; yet this problem of relieving the the boiler and retaining a working pressure had previously been stated and, as we shall show, had been solved by these prior inventors. But, whether as an improver upon them or as an independent inventor, if he had devised means which solved that problem, his specifications would have been full of it—at least it would have been plainly stated.

Third. He did not in fact devise any such means. Here we refer to a part of the testimony of the present record as to determinative facts of this matter now presented to this Court for the first time. The record at pages 201-208 inclusive contains the results of eleven experiments, which with others the Circuit Court characterized as "interesting and instructive," made by Mr. John C. Hoadley, M. E., with a valve made to a scale, part for part, in accordance with a tracing of the original drawings filed by Richardson in the Patent Office, (objection was made by complainant as to other experiments that they were made with valves constructed in accordance with Patent Office photo-lithographic copies of said drawings) with such modifications as to proportions as are named in the patent and were necessary to make the thing work at all.

For the reason that this Court was in the Crosby case deceived into disregarding the conclusions neccesitated by Mr. Hoadley's experiments in that case I have caused his record and experience as a civil and mechanical engineer to be inserted at length in the record at pages 111-113, to which the Court is referred for authority for the statement that he has no superior as an engineer, in experience, (forty-six years) and in the property and problems which have been entrusted to his ability and integrity, both by the government in the trying times of war and by capitalists and corporations, concerning matters which involved commercial life or death, in times of peace.

With his testimony he presented this valve of 1866, (marked Defendant's Richardson Patent of 1866) and with it all (eighteen) of its essential measurements, and compared them in a table (p. 204) with measurements, both of his own and of complainants' expert, Forbes (who is a comparatively recent graduate of the Patent Office) (p. 25) and also presented templates of a cross section of the valve. He is not cross-examined as to these experiments, for that would have been useless. Mr. Forbes does not experiment with this valve, for his experiments would have produced the same results. The only attack which is made upon this showing is that Forbes gives two reasons for his statement that this valve does not fairly represent the Richardson patent of 1866. He says (p. 210) first, that "the area of cross-section of the steam way is only 8.5 per cent., or one-twelfth of that of Richardson's original drawing, while the width of the structure is exactly as he directs—one sixty-fourth of an inch." And his second and only other complaint is that the valve was tried in a Kunkle valve-case. This patent does not show or describe any valve-case. A Kunkle case was used in these experiments solely as a matter of convenience and economy, *and it was punched full of holes on its top and around its side walls so as to avoid any possible effect upon the valve from the case.* It is not and cannot be stated in what respect this case in any manner effected the operation of the exhibit.

The first criticism made is not true, as is admitted by Mr. Forbes in answer to cross-question 6, (p. 221) and by reference to item 1 of the table on page 204, columns

7, 8 and 9, and comparing same with the first item of Mr. Forbes' measurements it will be seen that all these measurements of the steam way are proportionate.

The above criticisms upon defendant's experimental exhibit of the Richardson patent of 1866 are both abandoned in the brief of the learned counsel for complainant, Col. Thomas Wm. Clarke, and he admits (p. 8) that in making this exhibit "defendant made his reduc-"tion *exactly proportional* by linear dimensions." The stricture of this exhibit is exactly as required by the patent, to-wit, 1-64th of an inch for an ordinary spring. But *counsel* now complains and says that the huddling chamber is not large enough, and that it should have been constructed proportionally by cubic capacity, instead of by linear dimensions, to the huddling chamber of the patent drawings.

I do not know whether this criticism is made for the purpose of presenting something mysterious to the court, or for the purpose of leading defendant's counsel to waste valuable time in a useless discussion. The criticism is certainly without foundation. I, therefore, simply here state the answer to the objection made and refer to Appendix B hereto attached, where the matter is more fully discussed and more technically answered.

It there is demonstrated that defendant's experimental exhibit of this patent corresponds exactly with the original drawing of the patent as to *height*, *width*, and *area of cross section* of said chamber D.

The reduction made *was* substantially also proportional *to the cubic contents* of the huddling chamber shown in the patent, the difference between the two being eleven ten thousandths of an inch; and not only so, but the huddling chamber of the exhibit, as experimented with by defendant, was eleven ten thousandths of a cubic inch *larger*, instead of smaller, than the huddling chamber of a one inch valve reduced, as to this particular, in absolute, strict accordance with cubic contents. We respectfully refer to said Appendix B for a mathematical demonstration of this statement.

As to this huddling chamber, or extended valve head, the patent says (p. 65): "I add what is indicated "by all that portion lying outside of the said (second) "circle *in about the proportions shown in the figure* * * "forming the circular or annular chamber D, D, whose "transverse section shown in the figure *may be of any* "*desirable form or size.*"

Not only so, but it has been held by this court in the Crosby case, that *the* proportion of this patent to be observed strictly, is the proportion between the size of this stricture and the strength of the spring, the former being for an ordinary spring 1-64th of an inch, etc.

In the said Appendix the exhibit of this Richardson patent of 1866, with which the complainant obtained good results, is shown to be a cheat and a swindle, in that the overlap of the lip or flange constituting the stricture is very widely different from that called for in the patent. This was apologized for by my learned friend at Circuit,

but here again it is presented to provoke a useless discussion as an exhibit "made exactly according to the "measurements of the patent." (Complainant's brief, p. 8.)

No honest criticism either born of or outside of the Richardson patent of 1866 can be made upon the defendant's exhibit, which represents that patent, and with which complainant did not try any experiments, nor concerning which did it examine defendant's expert, and with which valve the best possible results obtainable is a reduction in boiler pressure of 15.9 per cent., *the average reduction in pressure of a series of fair experiments being nearly twenty-five and one-half per cent. of the working pressure of the boiler at which the valve popped.*

The point is not made that this patent of 1866 is invalid as not describing an operative device, for that point is not made in the pleadings, and it is conceded that a valve constructed in accordance with the patent can be operated for the purpose intended by the patent, to-wit: *to relieve* the boiler and to prevent a dangerous accumulation of steam in the boiler; but this demonstration that the valve of this patent will not relieve the boiler without losing from 16 to 38 per cent. of the working pressure in the boiler, is made to refute the many ingenious theories which have been put forward as to what this patent will do and what it is for, and to show that the patent is simply on a particular and precise device, having the sole object of relieving the boiler, the device being the pendant flange or lip, c, c, depending loosely around the valve head and constituting the stricture or

opening of less dimension than the opening at the ground-joint or valve-seat, which stricture is proportional in size to the strength of the spring used.

We, therefore, repeat as the third reason why this 1866 patent has nothing to do with the closing action of the valve, that a valve made in faithful accordance with the patent will not produce any such results as have been claimed.

Fourth. The fourth reason for the conclusion that this is not a foundation patent upon valves having a proper closing action, is that Richardson did not say anything about means to accomplish this object until 1869, when, in his patent of that year, he devised a back door or by-pass through which a part of the steam is taken off and placed a regulating cock at the back door, but without at all altering the size, shape or proportions of the thing patented in 1866, this adjustable back door being then, in 1869, *the thing* which he *added* to his patent of 1866 to accomplish the *alleged* purpose and the *alleged* attainment of the 1866 patent.

It would be interesting, though not profitable, to commence with the case of Ashcroft vs. the Boston & Lowell R. R. Co., decided by Judge Shepley in May, 1874 (I. B. & A., 215), and to follow that case into the Supreme Court (97 U. S., 189), in which case the late Mr. Henry Waters was the expert, and in which case this Court unequivocally said of a patent (Naylor's) older than Richardson's for the same purpose and composed of the same elements including the pendant flange or

lip, that said older patent must be limited to the exact device and arrangement shown in its specification and drawings, and to follow the litigation through the Crosby case, and the two Kunkle cases at Circuit, and following the various lawyers and experts, ending with the present learned counsel for complainant and with its present expert, to notice the various theories which have been vainly advanced for this simple patent upon this pendant flange or lip constructed as, and for the pupose set forth. Indeed, as this present case progressed through the Circuit Court three different and differing theories have been adopted as the exigencies of the case have seemed to demand. Some of these theories have been first that this 1866 patent was for a valve which would pop in opening and closing, and, therefore, covered all "pop-valves," (this compound word was invented to characterize this patent); second, that it was for a stricture of any construction and covered all safety-valves which had a stricture; third, that it was for an overlapping or variable stricture, that is to say, for valves in which the stricture remained constant until the overlap was passed, and covered all valves having a variable stricture; fourth, that it was for a valve in which the surface of the supplemental area bore the mathematical relation to the steam-way shown in the drawing of the patent; fifth, that it was a patent upon some mysterious mathematical proportions between these four elements, to-wit: the steam-way, the supplemental area, the spring and the stricture, in which each of these elements must have a certain proportion of size to each of the other elements, the credit for which

theory is in dispute in the record in this present case, complainant's present expert, Mr. Forbes, claiming that this part of the patent was original with him. (See p. 27, paragraph 1; p. 34, paragraph 5; p. 35, paragraph 4; and p. 103, X Int. 106).

I do not propose to discuss any of these fallaceous and misleading theories, but do now propose to demonstrate upon principle that they cannot be imported into this single and simple claim.

I have named above thirteen elements, each of equal dignity and importance in a safety-valve with the others, and each of them, except as to the pendant lip and the stricture which it forms, being, in the specification of this patent, given equal emphasis. For the lawyers and the experts to take, now this three and now that four of these elements, as may from time to time fit their case, and put the three or the four elements, as the case may be, with the element of the claim and to say that this patent is upon such a combination, is as illegal and inequitable as it is inscrutable and misleading to the public, for whom this claim was written. By familiar rules, that is to be imported into the claim which forms an operative and necessary connection with the things named in the claim to produce the desired result and nothing more. If the claim of a patent is such an elastic and uncertain thing as that, according to the exigencies of the case, this, that or the other element found indiscriminately in the specification can be taken and experimentally combined with the thing named in the claim, and the claim be construed

to cover said elements so combined, then certainly it is impossible for those most skilled in the arts and most learned in the law to construe any claim, and then it would be unsafe for anybody to do any business.

When we come to the question of infringement, we shall find that the record and the argument of complainant proceeds, on that question, solely upon identity of results. Identity of results in kind, though not necessarily in degree, must be present to find either anticipation or infringement. Identity of results, however, is never *per se* conclusive, for it is not results but means and their well known equivalents which are protected and form the subject matter of patents and the patent laws. The mistake of some experts in their struggles to be smart is to find some hidden or obscure function or functional operation which neither the skilled mechanic, nor the man of letters would divine, and, by naming it with some catch-word, some carefully selected general term which covers the thing set up as an anticipation or sought to be charged as an infringement, to conclude therefrom that the two are identical or are mechanical equivalents. Such puzzle working with inventions and with patents is of no assistance to court or counsel, and has no proper place in the careful application of the law. It is mystifying; it produces false issues and controversies; it misleads the courts into the determination of cases upon questions which should not be raised at all, and as a natural result that is said which in subsequent cases is prejudicial upon the real issues.

In this Richardson patent of 1866, the familiar law that the patentee must in his specifications distinctly point out and specifically claim the part, improvement or combination new with him has been complied with and he says that it is the pendant flange or lip, c, c, when constructed to operate as and for the purpose set forth. To ascertain what the latter part of this means we find from the specifications that it must hang loosely about and a little below the extended head of the valve-seat and be separated therefrom by about 1-64th of an inch for an ordinary spring, that space *being enlarged or reduced from 1-64th of an inch*, according as a weaker or a stronger spring is used, and that this space or stricture should be smaller than the opening at the valve-seat or ground-joint in order that the steam shall be backed up in the huddling chamber. Of the other ten elements named of the claim we have nothing to do, except that they are there to instruct tho public how to harness up this invention to make a practical use of it. A simpler and more specific claim never came out of the Patent office.

The claim of this patent we then state to be upon a pendant flange or lip *c*, *c*, forming a space for the escape of steam to the open air, of less size than the opening at the ground-joint or valve seat, and being of size about 1-64th of an inch. Such are the absolute requirements. Such is the whole of the subject matter of the claim. In going beyond this we go beyond that which any one skilled in the art would find in the claim upon that which Richardson, in this patent, stated to the public, he desired to

cover. This I understand to be the meaning of this court in its construction of this patent in the Crosby case. As to one part, however, of the opinion of this court in that case (the last paragraph of p. 10 of the Appendix A hereto), a construction has been contended for at circuit which is inconsistent with the other parts of that opinion, and is inconsistent at least with the law and the facts as presented in the case now at bar.

I am aware that upon the foregoing considerations, and especially upon those which are to follow, a judgment of non-infringement is in this case neeessary, and that such a judgment will dispose of all the issues between the present parties, both in this case and in the additional case now pending between them at the circuit; but in view of the new facts now proven, and in view of the comments and contentions had with reference to the opinion of this court in the Crosby case, and in view of the fact that other similar cases under these same patents are now pending at circuit, and in order to prevent further useless litigation, it is desirahle, even though it is not now necessary, that the court should give a further and an authoritative declaration as to what these Richardson patents, on their face, cover. The isolated language of the opinion of the court referred to in the Crosby case is, that this patent of 1866 covers, "a valve in which "are combined" (the numerals are inserted) 1, An ini- "tial area; 2, an additional area; 3, a strictured orifice "leading from the huddling chamber to the open air; 4, "the orifice being proportioned to the strength of the "spring as directed."

The three mechanical elements here named, to-wit the initial area, the additional area, and a strictured orifice leading from the huddling chamber to the open air, are, and for this identical purpose were, in 1866, confessedly old. We have learned from complainant (p. 26, paragraphs 6, 7 and 8) that the prior combination of devices containing all of those mechanical elements "perfectly served its purpose of relieving the boiler." In every case a housing, or harness, for the valve is as necessary as the initial area. There is nothing peculiar in Richardson's initial area; there is nothing precise or peculiar laid down as to his additional area, and we have demonstrated that there is no hidden meaning in this patent as to the closing action of the valve. The words "strictured orifice" in the above quotation are used in a technical sense, as defined in the other parts of the opinion.

We, therefore, claim upon the authority of this Court in the Crosby case that this patent of 1866 is for the pendant flange or lip *c*, *c*, producing a strictured orifice leading to the open air, *by which is meant an orifice smaller than the orifice at the ground-joint*, and of substantially 1-64th of an inch in size, and that that is what is meant by the court in that case in saying that the orifice must be proportioned to the strength of the spring *as directed*.

This is the length and breadth, the height and the depth of this patent, and we are able now to demonstrate that therein Richardson presented nothing new to the world.

ANTICIPATION.

In all the litigation which has characterized these two patents, and in the opinion of this Court in the Crosby case, the fact that the so-called Richardson valve has been introduced into very extensive use, and that the anticipatory valves have not been so introduced, is given great prominence. Under our laws, if the Webster patent had been in use for ~~fifteen~~ fifty years upon every single locomotive that ran up to the border of our country in Canada, it would form no defense to the Richardson patents, unless that Webster valve had been patented or published there. In the whole range of the patent laws the question of the use of a prior patent alleged to anticipate a patent sued upon can be raised for one, and for only one purpose. The Webster patent is presented to the court as an anticipation of the Richardson patent. The pictures of the patents on their face have not identical lines and do not appear to be precisely and exactly the same thing. It has been frequently held by this court that in such cases the question of identity is matter of proof and not to be passed upon by the court independent of proof. The necessary identity is that they shall produce the same results in kind, but not necessarily in degree, by substantially the same means and in substantially the same method or manner. Whether the use of the thing set up as an anticipation and the results demonstrated by such use be fifty or five years ago, or five weeks ago is immaterial. If a fair use of the thing demostrates that it does produce the same result in substantially the same manner and by substantially the same means the identity

of the two things as a matter of patent law must be decreed. It is an anomaly perhaps that a description of the Richardson patent in the *Sanskrit* language twenty-five hundred years old would anticipate his patent, although, as I have said, a very extensive use of the precise thing in a foreign country would not. To establish identity of patentable structure a use is material when the two things upon their face are not absolutely identical. In the Crosby case the use of the Webster valve set up was ridiculed and this Court was led to believe that the use then had did not demonstrate the identity of these two things. By the present record we have demonstrated that the Webster valve is constructed in substantially the same way; that it produces precisely the same results and by precisely the same means and that, in fact, the valve shown in the specifications and drawings of the Webster patent is a better valve than the valve shown in the Richardson patent of 1866 for every practical purpose yet suggested.

In the Crosby case experiments were made by the defendant with a valve made, as alleged, in accordance with the Webster patent, but differing therefrom in some matters of proportion or construction. The expert, Mr. Hoadley, did not take the illustrative drawings of the Webster patent for working drawings, (he emphatically and properly said he would be crazy if he had done so), but in constructing that valve he honestly endeavored to apply only that friendly mechanical skill which all patentees are entitled to in the application of their inventions. The complainant, however, whether rightfully or

wro gfully is not now open to argument, succeeded in convincing this Court that that valve was not a fair exhibit of what Webster gave to the world, and this Court said (see Appendix A) that "The prior structures never "effected *the kind* of result attained by Richardson's "apparatus because they lacked *the thing* which gave "success. *They did not have the retarding stricture* "which gave the lifting opportunity to the huddled steam, "*combined with the quick falling of the valve after re-* "*lief had come.* Likeness in them in physical structure, "to the apparutus of Richardson, in important particu- "lars, may be pointed out, but is only as the anatomy of "a corpse resembles that of the living being." (p. 4). * * "The Webster patent shows a huddling chamber "and a stricture. But the evidence shows that valves "made with the proportions shown in the drawings of "Webster work with so large a loss of boiler pressure, "before closing as to be practically and economically "worthless." (p. 8). And further, the problem as to the economical closing of the valve, which has been so much insisted upon, is stated and under the testimony in the Crosby case this Court finds that "This problem was solved by Richardson and never before." (p. 6.)

The facts and conclusive demonstrations of the case at bar show that, so far as anything described and claimed in the Richardson patent of 1866 is concerned, this problem was not solved by him, but on the contrary this problem was solved by Mr. Webster and those who preceded Richardson.

In this case numerous and accurate experiments with safety valves, made with the utmost exactness after the patent drawings of the Webster, Hartley and Waterman patents have been made. They were made (p. 120) by templates and patterns formed to fit the drawings made by Mr. Hoadley from tracings of the patent drawings, and correspond therewith not only in proportion, but also in size as well as in every detail of construction. The record at pages 120–123 contains the results of five experiments with such a Webster valve, each use being repeated from six to ten times, and it was then domonstrated that "every element and every combination of "elements to be found in the Richardson patent of 1866, "exists in perfection in this Webster valve made with "Chinese fidelity according to the wholly indefinite dia-"gram No. 3 of the Webster patent drawing." (Page 122.)

As in the case of the defendant's experimental exhibit of the Richardson valve, defendant's exhibit of the Webster valve, with gage, etc., was introduced for criticism and trial by complainant, but no other trials are made therewith. Complainant's expert, however, makes what he calls a Webster valve, and, for some cause best known to him, is not able to get good results therefrom. He tries experiments with his own Webster valve at two different times, and the second time gets (p. 217) improved results.

It, of course, could hardly be expected that he should obtain good results whether his exhibit be or be not substantially in accordance with the Webster patent.

In addition to the forty experiments, more or less, named above, and to make assurance doubly sure, more than two hundred and twenty-four (p. 161) careful and accurate experiments were made by Mr. Hoadley with both his Chinese embodiment and the complainant's embodiment of the Webster valve, the construction conditions and results of which experiments are given with the utmost particularity and completeness at pages 160 to 171, both inclusive, of the record, the necessary conclusions from which are thus stated (p. 171) by Mr. Hoadley.

"As a final result of all my numerous, careful and "laborious experiments with these Webster safety-valves, "I have ascertained :

"1st. That 'Complainant's Exhibit Webster, Fig. "3', purporting to embody the invention set forth in "Webster's Letters patent of Great Britain, No. 1955, "July 14, 1857, does sufficiently embody said invention.

"2d. That the application to said invention of the "lever and spring was a needless embarassment of its "action, since, as Webster's successor, the public is just "as free as Richardson was to adopt the simpler and "better mode of applying force to hold a safety-valve in "contact with its seat, namely, a direct-acting spring.

"3d. That notwithstanding the inconvenience of "the lever, 'Complainant's Exhibit Webster, Fig. 3, is "a good, practical, useful safety-valve, and might be put "to use judiciously upon any boiler of suitable size work-"ing under a pressure of about one hundred pounds per "square inch above atmospheric pressure.

"4th. That said exhibit, just as it was when I "experimented with it, would prevent an objectionable "rise of pressure above that at which it should be set "not much exceeding one hundred pounds per square "inch — would promptly relieve a boiler of suitable size, "say fifteen to eighteen horse-power, of all the steam it "could be made to generate, and would close promptly "at any desired reduction between 5.9 per cent. and 12.9 "per cent., which are entirely within limits desired in "practice, in proof of which I testify that I prefer to set "the safety-valves of portable steam engines manufac- "tured for me under my patents so as to give a reduc- "tion of about twelve pounds at pressures ranging from "100 to 120 pounds.

"5. That "Defendant's Exhibit Webster, Fig. 3," "is substantially identical with "Complainant's Exhibit," "purporting to embody the same invention so far as all "the essential features of said invention are concerned, and "is a better safety-valve only in so far as it is a little bet- "ter made, and in that it discards, as did Richardson, the "lever and springs, and adopts, as Richardson also did, "a direct-acting spring.

"6. That this exhibit, "Defendant's Exhibit Web- "ster, Fig. 3," is a good, useful, practical safety-valve, "and would be a judicious satety-valve to apply to any "boiler of fifteen to eighteen horse-power at a pressure "of about 100 pounds per square inch above atmospheric "pressure.

"7. That Webster's patent, from the description, "specifications and drawings, of which two independent "exhibits have been made, one with friendly skill, intent "on obtaining usesul results, the other with sufficient skill "(presumably adverse), to demonstrate, if possible, that "useful results could not be obtained by following said "description, specifications and drawings, which exhibits "are in fact substantially alike in operation, and which "are both useful, practical embodiments of the invention "set forth in said patent, contains necessarily a clear, "full an daccurate description of said invention."

The illustrative diagram here inserted is copied, upon an enlarged scale, by photo-lithography, from the diagram opposite page 164 of the record, and shows plainly the action both of complainant's and of defendant's embodiments of the Webster patent throughout the whole range of the more than two hundred and fifty experiments tried therewith.

In this diagram the horizontal center line, C, D, represents the top surface of the ring which bounds the extended valve-head and the scale on the right, running from this line upwards to 0.25 and downwards to 0.15 represents the height or the depth of the pendant lip or flange above or below this ring. The scale at the bottom running from 0. to 60 represents the reduction of the boiler pressure for the different positions in which the valve was adjusted as directed in the patent up and down upon the valve stem, and the percentages of these several reductions are given in small figures at the sides of the irregular lines. These irregular lines represent the

performances of the complainant's and defendant's embodiments of this Webster patent respectively, line E, F, G, H, the complainant's, and the other lines the defendant's.

An inspection of this diagram shows that the Webster patent and publication of 1857 gave to the world a valve, having an initial area, a supplemental area, a contracted outlet from the huddling chamber which is formed by the supplemental area and a pendant lip or flange at that point, which when operated with a spring, as Sir Robert Hooke said in 1678, all springs should be adjusted, accomplished not only the sole object of Richardson's patent of 1866, which was to relieve the boiler, but also accomplished the object of his 1869 patent, in that the valve would close uniformly within three or more per cent. of the working pressure. And not only so, but this very closing action in the Webster valve is produced *by an adjustment of the pendant flange*, or stricture, and the Webster patent contains specific instructions therefor.

Two constructions (p. 47) are shown, corresponding to the two constructions described in the Richardson patent, one with the pendant flange or lip outside of the extended valve-seat, and the other with a flange of less diameter than the upward projecting periphery of the extended valve-seat. The amount of overlap shown (p. 149, Cross Int. 72) in figure 3 of this patent is "from "one-half inch to nothing. The wall around the valve "being one-half inch high for provision for adjustment, "and the direction is to adjust at any hight you please." Specifications are not given for any particular strength of

spring, nor for any particular initial pressure, whether fifty or one hundred pounds, nor for any particular reduction desired, whether five or fifty per cent. The directions of the patent are " upon the stem, c, of the valve I " place a collar or flange, e; the said collar or flange, e, " is capable of sliding on the valve stem c, and is fixed at " the desired hight by the screw, f," (p. 46); again (p. 47) " By adjusting the said sliding collar or flange e to " *different hights* on the valve-stem, c, the action of the " steam upon it may be regulated "; again " h, represents " the sliding collar or flange as capable of being adjusted " *to any desired hight* above the valve k in the interior of " the case or hollow cylinder i."; and again (p. 47 ll. 2 & 3) " the sliding collar or flange e may be brought down " on the stem c so as to rest on the top of the valve a." It is worthy of special remark here, although it will be more in point hereafter, that on this same page (47) of Webster's specifications he describes the use of the helical spring around the valve stem for which spring arrangement Richardson discarded the steel-yards which are mentioned in his, Richardson's, patent.

Thirty-five different adjustments of the flange or lip between the extremes of 0.125 inches below the level of the ring of the extended valve-seat and 0.25 inches above that level are experimented with, with many trials and observations at each point, these experiments including not only defendant's, but also complainant's,embodiment of this Webster patent, and with both most excellent results are attained, as good as ever were attained with the so-called Richardson valve.

It is a determinative coincidence that the Richardson valve and the Webster valve *with equal overlap* produces equal reduction of pressure before closing.

With an overlap of 0.02 in. (p. 163, ex. no's 25 & 26, col. 3) the Webster valve gave a reduction of 16 to 20 per cent. (col. 10). This overlap is precisely like the overlap in Richardson's 1869 patent drawing. In the experiments with the Richardson valve made in strict accordance with his 1866 patent (p. 207) the reduction is the same for the same overlap, (p. 204, item 14. col. 9).

Complainant's exhibit of the Richardson patent of 1866 avoids equal or even greater reduction by falsifying the overlap, making it .01 in. instead of .039 in., or at the very least two and one-half times the width of the stricture which is 1-64 in. = .0156. (.0156 × 2½ = .039)

Complainant's expert admits (p. 32) that by reason of this adjustability in the Webster patent "the amount "of reduction of boiler pressure may be varied within "certain limits."

Without specially noticing the dogmatic talk of complainant's expert contained in the record in which he derides these faithful experiments with a Webster valve, we find complainant's objection to this demonstration concerning the Webster patent to be as stated in its brief, pages 26 to 36, as follows:

First. That an exceptional steam supply, e. g. a boiler in which the steam could be raised from 41 to 100 pounds pressure at the rate of 7¾ pounds a minute, was

used. When it is remembered that the design of both Richardson and Kunkle was to produce a safety-valve for locomotive boilers having intense blower attachments, and which are so crowded with the steam supply that frequently the safety-valve will open and close a dozen times in almost as many seconds, it seems hardly worth while to say that Richardson's patent does not relate to any particular boiler, but was intended for all boilers, or to say that because the experiments tried with the Webster valve were tried with a singular and severe boiler pressure to conclude that they are deceptive, is illogical, and not all in point.

Second. That at different experimental points the loss of boiler pressure was not proportional, i. e., that when it was working at different points where there was a considerable reduction, the ratio between the reductions at those points was not the same as the ratio between the different points when there was a small reduction. This proves nothing.

Third. That in this Webster valve the distance of the lift of the valve "was hardly 27 per cent. of the least "allowable lift" (pp. 28, 29, 30 and 31). Now, however this may be, Webster, Richardson and Kunkle have said nothing about the amount which the valve should lift, and it is a sufficient answer to all this to say that the valve was made with the strictest Chinese fidelity to the Webster drawings, and it did just what *is claimed* the Richardson valve will do, but which the Richardson

valve, made in strict accordance with his patent, will not do, and by the same means and in the same manner as claimed for Richardson.

Fourth. Some isolated instances among the experiments which Mr. Hoadley made with *complainant's* embodiment of the Webster valve are selected (p. 34), some of the intermediate data between the instances cited being omitted, to show, forsooth, that in this particular valve made by complainant, presumably for the purpose of showing that it would not work, there is a disparity in "the uniformity of opening pressure with the "same adjustment of the spring" (p. 33). Although in the instances compared there were different adjustments of the peneant flange, or lip, and although it is admitted (p. 34) that "a seeming conformity in results to adjust-"ments may be made by averaging the percentages of reduction" as indicated.

It again is a sufficient answer to the Richardson patent of 1866 to say that defendant's expert took *complainant's* embodiment of the old Webster patent, and, in uncontested experiments, it, in his hands, by the same means not only produced an adequate relief of the boiler, but also closed within five pounds of the boiler pressure at which it opened.

Fifth. Another criticism is based upon the fact that in the experiments with defendant's Webster valve a direct acting spring was used, and in some of the experiments a screw thread was cut upon the valve-spindle. Now, if thereby knowledge acquired from or subsequent

to the date of the Richardson patent was injected into the Webster patent, the point would be well taken. That is not the fact. Richardson in his patent refers four times to the load upon the valve. Once he calls it (p. 64) the "spring or scales," and three times he calls it (p. 65) the "spring or balance," thus referring, as do the other and prior patentees, to springs, helical and others, applied directly or indirectly, to levers and weights, and to steel-yards indiscriminately. Ritchie, in his patent of 1848 (p. 45), claimed his compensation flange "without regard to the manner in which such valves may be "weighted," and in his specifications (pp. 44, 45) he says the helical spring, i, may be placed either above or below the valve. Complainant's expert says (p. 26) that "the result is also not altered in the cases where, instead of using a lever with a spring balance at the end, a large spiral spring is employed, pressing directly upon the valve," and (p. 25) he says, as to the prior art, that all the loads for the valve named above had been previously used.

As stated above, the Webster patent itself describes the use of a helical spring.

The interchangeable use of a set screw, as shown in the illustration of the Webster patent, or of a sleve and screw thread, was also open to the public, as witness the fact that complainant in its construction and use of the Webster valve adjusted the valve proper and its projecting flange upon the valve stem, just as defendant in part did, viz., by a sleve and set screw. (P. 167.)

But it may be contended, to support the validity of this patent, that although the stricture of the Richardson patent, as well as the supplemental area, both as to the construction, the operation and the result, be old, yet, the patent should be sustained, for Richardson developed the law which, with such a stricture, governs the strength of spring to be used. The answers are:

First. He does not so say when he comes, at the end of his patent, to point out to the public what he has invented, but says his patent is upon the pendant flange or lip c. c., forming a stricture of about a sixty-fourth of an inch for the springs then in use. To use the language of the courts, it would have been perfectly easy, if he had really invented any such thing, to have said so in an added or a substituted claim.

Second. He has not, in fact, told the public how to select a spring to fit the stricture, but that law was developed and published in 1678, by Sir Robert Hooke (p. 221). After the instructions of the Richardson patent and all that money and the skilled experts have added thereto, is taken advantage of, yet, to this day, after the valve is constructed and finished different springs have to be tried and adjusted before the valve can be placed upon the market, or can, with any safety, be placed upon a boiler.

Third. Even if it could fairly, and in justice to the public, be said, that Richardson added to the Webster the proportions of Ritchie and the law of Hooke, which is not even faintly indicated in the claim, then we would say

that in making that aggregation he had not made a patentable combination in the meaning of the patent law. But these contentions as to a patent upon springs are not born of this patent.

We therefore confidently contend that in the light of the conclusive testimony now newly presented to the court, this patent should be decreed to be anticipated and invalid. In the language of Judge Blodgett:

"I will add that from the experiments made by the "experts in this case as shown in the proof, it seems quite "probable to me that the improved practical results ob- "tained by the Richardson and Kunkle valves over those "previously in use is as much attributable to their im- "proved finish and mechanical perfection as to any newly "invented element they contain. * * * These old "English and American valves were intended to work on "substantially the same principles as Richardson's, and "may have failed for lack of skill in making or using "them rather than because their inventors had not con- "ceived the true principle upon which they were to work. "Webster, it seems to me, shows not only the stricture, "but the element of adjustability is clearly shown by the "provisions for raising or lowering the auxiliary plate or "flange upon the spindle of the valve so as to increase or "diminish the opening for the escape of the steam from "beneath the extended area of the supplemental flange."

INFRINGEMENT.

The Kunkle valve differs in every operative element and combination from the valve passed upon in the Crosby case. The present question of infringement is entirely new. The valves now changed also differ in structural elements, in combination and in operation from the valves shown in the Richardson patents.

I have said that as this case progressed in the Circuit Court the complainant, upon the question of infringement, as the exigencies of this case, and as the exigencies of the announcements of the courts in other cases seemed to require, has adopted three successive theories as to the proper construction of this Richardson patent of 1866. The first theory (p. 27) was that "Mr. Richard-"son's invention consisted essentially in proportioning said (huddling) chamber, *its horizontal area* and its "escape opening *to each other* and to the degree of ten-"sion of the spring," and (p. 34) there is an "absolute "necessity of maintaining the relative conditions of "amount of supplemental *surface*, strength of spring and "size of 'stricture.' This matter of intricate triple pro-"portions is abandoned, and (p. 42) the *stricture* is said "to be the micrometer measure of *all* this work of "spring, extended surface, and expansion chamber." And it is admitted (x ints. 65–73, pp. 95–97, and see specially x int. 82, pp. 98 and 99) that the patent does not give specific directions for any such proportions. As to the closing action of the valve (x int. 106, p. 103) the

theory advanced is admitted to be original with complainant's expert.

The second theory which is relied upon in complainant's brief, and is relied upon in complainant's expert's rebutting testimony, is that the stricture depends upon the difference between the size of the escape opening to the atmosphere and the size, that is to say, the cubic contents (not "surface" or superficial area) of the huddling chamber, instead of the difference between the size of the escape opening and the ground-joint, it being now contended that the term "valve seat" in this patent does not refer to the ground-joint, but to all the chamber, passage or space within the pendant lip or flange. And the third and most extravagant theory relied upon (p. 215) is that in defendant's valves there is a stricture at the top of the valve case or housing.

The two following desperate and "latter-day" propositions upon which complainant *now* rests its case seem to require reply, viz.:

1. That the stricture which Richardson patented consisted in a difference between the size of the escape opening to the air and the size of the valve-seat, meaning by "valve-seat" not the ground-joint, but all the intermediate parts between the steam way or inlet from the boiler, and the escape opening, and,

2. That within the meaning of the Richardson patent, the escape opening, and strictured orifice is to be found, in the Kunkle valve, in the top of the valve case, and that this escape opening is smaller than said inter-

mediate parts and, therefore, a then well-known mechanical equivalent for the device described and claimed by Richardson is to be found in defendant's valve.

In discussing the variable stricture which Richardson thought was new with him, all the parties to this and to former litigations under these patents, down to very late in the history of this case at Circuit, have continuously used the term "valve-seat," and the term "ground-joint" as interchangeable and identical in meaning. The Supreme Court so used these terms in the decision in the Crosby case.

Complainant's expert (p. 26, § 7) says "its seat *or* ground-joint," and at page 28, § 4, he repeats this expression, and with great particularity describes the closing action of the valve as due to the variable stricture, i. e., to the difference between the size of the opening *at the ground-joint* and the size of the opening at the periphery of the extended valve-seat.

This Court in the Crosby case (appx. bottom p. 6 and top p. 7, and bottom p. 11) first says that, according to Richardson's directions, "the *apperture* between the "valve and *its seat* is always *greater* than that between "the flange and the upward projecting rim"; and subsequently defines the seat of the valve as follows: "In "the Richardson valve all the steam which escapes into "the open air escapes from the huddling chamber "through a stricture which is smaller than the apperture "*at the ground-joint*."

His Honor, Judge Blodgett, in deciding this case at Circuit, said (15 Fed. Rep. 732): "This, as I understand

"it, is Richardson's definition of the construction and "operation of his stricture, and requires, in specific terms, "that the space for the escape of the steam between the "flange and the ring encircling the extended valve-head "shall be of less area than the area of escape at the "valve-seat, a peculiarity not provided for in Kunkle's "valve, and evidently not intended to be a part of his "mechanism as, from the time the steam passes through "the *ground-joint* of the Kunkle valve, it is nowhere "throttled and compelled to pass through a less area on "its way to the open air, its exit passages increasing "constantly in area instead of diminishing."

We find in the Richardson patents many times repeated, we find in a theoretical examination of the device described, we find in the practical use of that device, we find in the mouth of complainant's expert (until forced in the same record to advance another opposite and rediculous theory), and we find in the prior adjudications in the Circuit Court and in this Court, this *sine qua non*, this cardinal and indispensable element, this, as the sole subject matter of the patent of 1866, to-wit, a pendant, loosely overlapping flange c, c, separated from the extended valve-seat by about one sixty-fourth of an inch, forming a *variable* stricture and constructed so as to produce this result to-wit, that in the initial and in the closing operation of the valve THE INLET FROM THE BOILER (at the ground-joint) SHALL BE LARGER THAN THE OUTLET TO THE ATMOSPHERE.

Kunkle has no such overlapping flange, he has no such variable stricture, and KUNKLE'S INLET FROM THE

BOILER MUST ALWAYS BE SMALLER THAN HIS OUTLET TO THE ATMOSPHERE.

When complainant in its rebutting or closing testimony (p. 213 et seq.) seek to find a stricture (confessedly not variable) in the Kunkle valve outside the valve mechanism proper and in the top of the valve case or housing, it is thereby practically admitted that there is here no stricture, much less is there a Richardson overlapping or variable stricture, and it necessarily follows that defendant does not use the device or combination which Richardson attempted to cover by his claim upon ~~upon~~ "the circular, or annular flange, or lip c, c, constructed," etc.

But to make assurance doubly sure, we add the following demonstration of the conclusion to which the Circuit Court arrived.

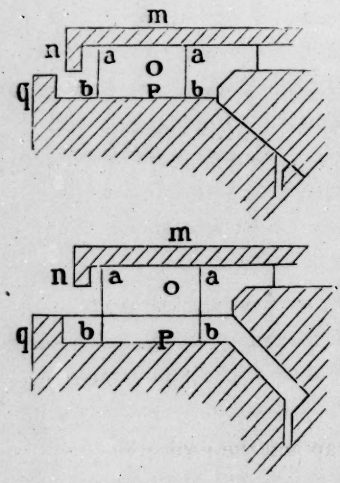
The four drawings, enlarged five fold, here inserted, show (Figs. 1 & 2) a Richardson valve under his 1866 patent with a proper overlap of the pendant flange or lip, in Fig. 1 the valve being closed and in Fig. 2 the valve being raised from its seat the distance of said overlap, and in Figs. 3 & 4 the same without any overlap when the valve is seated, and in Fig. 4 the same valve, raised as before. Figs. 5, 6, 7 & 8 show the same illustrations for the patent of 1869. It appears from an inspection of these drawings that, with the overlap, a stricture is formed by reason of the fact, and solely by reason of the fact, that the area of the escape opening, until the overlap is surmounted, is smaller than the escape opening at the valve seat or ground-joint (Figs. 1, 2, 5 & 6); and

that if the overlap be not present, no stricture is found for the reason that in that case, in operation, the escape opening to the air is at all times larger than the escape opening at the valve seat or ground-joint, but never larger than the intermediate chamber. (Figs, 3, 4, 7 and 8). These illustrations and statements and what is to follow are inserted with special reference to the following clear and true statement made by Richardson in his patent of 1869, (p. 68 and 69).

"If the projecting rim *q* were in the same plane "with the lower edge of the flange *n*, the diameter of "these parts being greater than that of the valve-seat, on "the lifting of the valve and cap the area of the opening "between the flange *n* of the cap and the projecting rim "*q* would be greater than the area of the opening be- "tween the valve and its seat, just in proportion as the "diameter of the one is greater than the other, and the "steam escaping from the valve would pass unchecked "between the flange *n* and rim *q*, and would not exert "any force against the surface of the annular space *o*; "but as the rim *q* extends above the lower edge of the "flange *n* of the cap-plate, it follows that *the aperture be-* "*tween the valve and its seat, by the lifting of the valve,* "IS ALWAYS GREATER *than the aperture between the flange* "*n and the rim q*, and hence the escaping steam, by its "elastic force, will act against the surface of the annular "space *o*, to assist in lifting and holding up the valve un- "til the pressure in the boiler or generator falls below "the pressure by which the valve was first opened."

Upon complainant's assumption that the "area of

" the opening between the valve and its seat " is the area



of opening between the underside of the flange *m* and the upper surface P of the extended valve head, which (see cut in margin) equals the height of the annular chamber O (a, b) it would not and could not be true that " if the projecting rim *q* were in the same plane with the lower edge of the flange *n*," on lifting the valve and cap the area of the opening between the flange *n* and the projecting rim *q* would be greater than " the opening in the chamber O." No possible opening between *n* and *q* could ever be greater than the opening a, b, between the underside of the flange *n* and the upper surface P of the extended valve seat. The language of the patent is, however, true with reference to the true valve seat which is the ground-joint.

It would be true that if the rim *q* were, before the valve commences to lift, in the same plane as the flange *n*, " the escaping steam from the valve would pass un- " checked between the flange *n* and the rim *q*, and would " not exert any force against the surface of the annular " space o;" but this would *not* be because the outlet at *n*, *q*, was larger than the passage through o, (for it would *not* be larger, nor nearly as large,) but because, as

Richardson says, this outlet would be larger than the inlet at the opened "valve-seat," i. e., the true and only valve-seat, which is at the ground-joint.

Again, Richardson says: "The aperture between "the valve and its seat, *by the lifting of the valve* is al- "ways greater than the aperture between the flange *n* "and rim *q*, and hence the escaping steam by its elastic "force will act against the annular space o," and he expressly says that the reason why this relation of area will exist and this effect will follow, is because "the rim *q* "extends above the lower edge of the flange *n* of the "cap-plate, it follows that the aperture between the lifted "valve and its seat"—the *inlet* into the huddling chamber—"is always greater than the *outlet* at the narrow "space"—the stricture.

This language points out and emphasizes the indispensable importance—the absolute necessity of that feature of his "narrow space," or stricture, which he calls the "lap"—which Mr. Forbes, Mr. Hoadley, and other expert witnesses have called the "overlap," or variable stricture. It is "by reason of the lap," Richardson says, that this "narrow space presents a less area of opening "for the escape of steam than is produced at the valve- "seat." (R. p. 66.) And he later, in the same patent, not only describes the lap, and says that it is "hence"—i. e., by reason of the lap—that steam is made to exert elastic force in the chamber (annular space) o, but he in detail explains that the omission of the lap would destroy the indispensable relation between outlet and inlet, and

prevent the exertion of any elastic force of steam in the annular space o.

Now, this full, explicit, repeated explanation, in two forms—positive and negative—showing what results flow from the lap, and what futility would result from its omission, is perfectly true of Richardson's stricture, which is, and was first, last and always, an overlapping variable stricture, *i. e.*, a narrow space for the escape of steam between the walls, or rims, or boundaries, the one stationary the other rising with the opened valve, the one overlapping the other, so as to maintain a constant area of opening in this "narrow space," until the "lap" was surmounted, and meantime the opening at the valve-seat, *i. e.*, at the ground-joint, growing continually larger as the valve rises.

Richardson's buddling chamber *must* have an overlapped stricture as an outlet for steam to the air, and a larger inlet *from the boiler*. As to the size of this chamber, he only says, it may be "of any desirable form or size." If the all important relation under consideration be, indeed, if, according to complainant's latest contention "the relation of the area of the stricture spoken of" be "an operative relation to any area between the valve and "the seat outside of the ground-joint, or, in other words, "to the transverse area of the huddling chamber on any "diameter within it." (Comp's brief p. 12). If *this* be the all important relation on which the successful operation of Richardson's valve absolutely depends, how can it be said that he has specified this relation in the only lauguage relating to it; *i. e.*, "whose transverse sec-

" tion, shown in the figure, may be of *any* desirable form " or size?"

Notwithstanding the necessity resting on complainant's counsel to take *some* method to evade the plain and positive description of the invention given by Richardson in his patent as to his stricture, lap, and relative area of inlet and outlet to his huddling chamber, it is astounding that he should take the ground he does, in view of the plain language quoted from the patent, in view of his own expert's testimony as to the unimportance of the size of the supplemental (huddling) chamber, and as to the importance " of the area of the overhanging " flange, which should not be confounded with the " *cubical* capacity of the chamber." (R. p. 90, cross int. 29.)

It is true that after the invention of this absurd theory complainant's witness, Forbes (x int. 14, p. 223), takes this ground, but in doing so contradicts himself, contradicts Richardson, and stultifies himself.

The capacity of this huddling chamber is of necessity small, less than one cubic inch in a 2¼ inch valve, when the valve is lifted at its highest, 0.10 inch (R., p. 204), and it would always be filled with steam in a small fraction of a second after the valve was lifted from its *seat*, at the ground-joint, by initial pressure. Once filled—the air expelled—the pressure within the chamber (D of the 1866 patent, *o* of the 1869 patent)—*must* depend on the relative size of the inlet, *from the boiler*, and the outlet, *to the air*, i. e., on the relative area, (1) of

opening at the outer circumference *of the ground-joint*, which is the inlet, (the circumference in inches, multiplied by the lift perpendicular to the inlet) and (2) of the horizontal area of the stricture, (until the "lap" is surmounted, and after that, the oblique or conical area between the lower, inner angle of the lip, and the upper, outer angle of the extended valve-seat) which is the outlet. As long as the area of inlet increases fastest, the pressure in the huddling chamber will rise; but when (on the lip rising to the level of the extended valve-seat) the outlet increases fastest, the pressure in the huddling chamber will fall.

That is the stricture which Richardson thought he invented. That is what Richardson says, that is what Hoadley says, that is what Forbes says, until compelled to stultify himself, and that is the plain common sense of the matter; just as the amount of money a man can save will depend upon the difference between his income and his outgo, and not at all upon the size of his trousers pocket.

Now, in defendant's valve, steam, on escaping from the slightly opened ground joint, escapes through a series of passages which grow gradually larger all the way, and is nowhere contracted, or "huddled," but goes on with pressure constantly diminishing till it reaches the open air. This uninterrupted, progressive expansion of escaping steam is due to the absence of a narrow space or

stricture,—to the absence of overlap. Indeed, as there is no stricture, no lips, rims, or walls of any stricture, less in area than any preceding space, opening, or orifice, there can be no overlap, for there is nothing *to be overlapped.*

No *compression* is possible in any of the Kunkle passages, and any malformation, any mal-adjustment, or any tampering with a Kunkle valve which should result in producing any "huddling," or intermediate pressure between the open ground joint and the open air; anything at all resembling the operation of escaping steam such as is indispensible in Richardson's valve, whether of 1866 or 1869—any impediment to free escape and continuous expansions with constantly diminishing pressure, would be fatal to the operation of such Kunkle valve.

Kunkle's valve owes its supplementary lifting power, by which it is raised from its seat, immediately after it is slightly opened at the ground joint by initial pressure on initial area, higher than such initial pressure could lift it, to two forces; one of which is common to Beyer, Naylor and many other inventors, both earlier and later, including Richardson; that force is direct impact of escaping steam upon an extended flange outside of his valve head. The effective presence of this impact is admitted as to the most of the valves, ancient and modern, mentioned in the record, as for instance by plaintiffs' expert (p. 33) concerning the Hartley valve, this being one among many instances appearing in the record; and counsel for plaintiff is corrected and taught (Cross. Int. 206, p. 189) that this force is "as the weight of mole-"cules of steam multiplied by the square of the velocity.

"Double the velocity would give four times the mo-
"mentum."

The other, a newly introduced force, never before actually introduced in any combination into the mechanism of a safety valve, is the rarification of the atmospheric air in an air-tight chamber above the enlarged head of the valve, and the formation of a partial "vacuum" above the valve, causing a differential atmospheric pressure to act upon an area equal to the entire area of the valve and its flange.

It is with reference to the partial vaccum produced over the valve-head by sucking the air out between the valve-head *h*, and the pendant flange *f* of the case, (see drawing Kunckle C), that we have said that a comparatively loose fit is here necessary and essential.

All these points, namely: 1. The entire absence of compression, or "huddling." 2. The force of impact of escaping steam, without recoil. 3. The lifting force of "suction," or differential atmospheric pressure; are demonstrated by experiment No. 15, with a Kunkle safety-valve having a steamway 2¼ in. diameter, as related in detail in the record, pp. 134, 135, 136, and 137.

The first point—the absence of compression at the only place where compression could assist in lifting or in holding up the valve, namely: beneath the flange on the valve head, is proved by the fact (p. 135) that while the *upward* force against the flange, due to impact of escaping steam, was 7 lbs. per square inch, the downward

force, or pressure on the bottom of the channel through which the same steam was flowing out, was only ⅛ lb. on a square inch. Now elastic force, due to compression or huddling is equal in all directions. Only the momentum, or force of impact, is exerted in the direction of motion of the impinging body. That impinging body in this case was steam. That force, 7 lbs. per sq. in., was exerted on an area outside of the valve head, of 2.423 sq. in. and amounted to 2.423 x 7=16.961 lbs. avoirdupois auxilliary lift. The initial lifting force, 101 lbs. per sq. in. on initial area, 3.97 sq. in. area, =400 lbs. The auxilliary lifting force due to impact of escaping steam then was (16.961 divided by 400=.0424) 4.24 per cent of the initial lifting force. The compression of the spring for 100 lbs. per sq. in. was ⅝ in.=0.625 inch, and therefore for 101 lbs. it was .631 in. Now, 4.24 per cent. of .631 is 0.0268 in., which would be the additional lift of the valve due to this force alone, provided this full impact could be exerted if there were no co-operating auxilliary lifting force. But while merely "warning," the impact was only 3 lbs. per sq. in. (p. 135), and then, when this force of impact was acting alone, its lifting force was 7.27 lbs., equal to 1.82 per cent., and the additional lift, or opening of the valve due to this force of impact, was only .0116 inch—too little, by itself, to do more than "warn,"—too feeble to produce a "pop."

But the current of steam flowing out of an orifice at the ground-joint really less than 1–100th inch (.0082 inches) wide, (measured at right angles to the surfaces of the ground-joint :—.0116 x .70711

= .0082) sufficed to draw out, to *suck* out, by its own constantly enlarging volume, and diminishing pressure so much air from under the cover of the case, over the valve-head, as to reduce the pressure of air within that chamber 3.75 lbs. per square inch *below* the pressure of the free air outside.

This differential atmospheric pressure of 3¾ pounds per square inch, acted on the whole area of the valve-head, flange and all. There is a slight error of proof-reading on page 135 of the record. The area of flange on valve-head is not as there stated, 10.349, or 10.3, but 8.71 square inches.

The lifting force, then, is equal to 3.75 lbs. per square inch on 8.71 square inches, and 8.71 x 3.75 = 32.663 lbs. This is almost double the full effect of impact, and more than four times (4.4 times) the effect of impact while warning. Now, adding 16.961 and 32.663, we have 49.624 lbs. auxilliary lifting force, which is equal to 12.4 per cent. of the 400. lbs. initial lifting force, and 12.4 per cent. of .631 = .0782 inch uplift of the valve from its seat at the ground-joint. This vertical uplift, multiplied by the cosine of 45°, = .70711, gives (.0782 x .70711 = .0553) the width of opening at the ground-joint measured at right angles to the surfaces of the ground-joint, i. e. the actual thickness of the stream of steam flowing out of the boiler = 1–18th in.; and this free and full relief reduces the pressure within the boiler to 99 lbs. per square inch from 101½ — the popping pressure, say 2½ per cent. (there is a small error on page 134, R. 1½ instead 2½), in sixteen seconds from the

warning. The reduction of lifting-force on the initial area was: 3.976 x 2.5 = 10. lbs. This suffers the valve to fall .0158 inches, enough to greatly diminish both impact and suction, and the valve immediately closes with a "pop."

Now, not only does "huddling" contribute nothing to this action, for the sufficient reason that there is no "huddling," no "huddling chamber," no "stricture," no narrow space, no "lap" or "overlap," no place where the steam-passage is less in area of cross section than at any preceding place — absolutely *no* place where the outflowing steam *can* pass from a wider to a narrower, from a larger to a smaller passage; not only is there no "huddling" possible in a Kunkle valve, but the introduction of any impediment which should prevent continuous enlargement of volume and diminution of pressure, any "huddling," anywhere, would be fatal to the operation of a Kunkle valve. Obstruction at the outlets from the case would *force steam into* the chamber under the cap above the valve and cause the valve to *close* instead of aiding it to lift.

When the valve is lifted the under side of its flange is about level with the lower edge of the guiding rim depending from the cover, and the narrow crack between this guiding rim and the edge of the flange adjoins the flat channel beneath the flange through which steam flows out. If, now, for any reason, from any cause, *pressure* is substituted for free expansion in this passage, *equal pressure* must be formed in the chamber over the valve, and the valve forced down, because the

area of the valve-head, including the flange, 8.71 square inches is more than 3½ times (3.6 times) the area of the flange acted on by escaping steam.

Here, in this "vacuum," this "suction," this differential atmospheric pressure, brought into action by the Kunkle mechanism for the first time in the history of the art, we have a new element entering into combination with the very old, old element, an over-hanging lip or flange, and a useful result obtained, not only without the aid of Richardson's mechanism, but to the absolute exclusion of any and all mechanism which can in any degree or in any manner perform the function his "stricture" by reason of its "lap" can perform, i. e. "huddling" escaping steam.

1. Richardson has no device which can form any degree of "vacuum."

2. Richardson's device acts by intermediate compression in a huddling chamber, "by reason of the lap," and, as he truly says, could not act "if the projecting rim q were in the same plane with the lower edge of the flange n," i. e. if there were no "lap."

3. Richardson needs no other auxiliary lifting power, because by his overlapped stricture he can get as much as he needs, and has at his command far more than he needs.

4. Kunkle could not get along without more auxiliary lifting power than he gets from *impact* on his extended flange, which was found insufficient by numerous inventors from early times. Having no "stricture," no "narrow

space" less in area than any preceding space, no overlap, no "huddling" and no place for huddling, he introduces for the first time in the history of this art the auxiliary power of "suction," "vacuum," or differential atmospheric pressure.

What has been said negatives the idea of there being a Richardson stricture or any kind of a stricture at the opening in the top of Kunkle's valve-case, and shows that the opening at this point is and must, in any successful operation, be greater than the opening at the valve-seat or ground-joint. The valve-case serves these purposes only, to keep grit and dirt from the valve-seat, to prevent tampering with the spring, and to give free exit for the steam from the valve proper.

It is in point, however, to remark, *first*, that the openings at the top of the case are manifestly and of necessity larger than the opening at the valve-seat or ground-joint; *second*, that, for the reason that this ridiculous theory was first advanced as the case was closed, no testimony is given of actual measurements to show that the openings on the top of the case are in fact larger than *any* space between them and the valve-seat, but, it being incumbent upon the complainant *to prove* the presence of a Richardson stricture, it is fatal to complainant's case that, as to the valves charged, there is not (and can not be) one particle of testimony to show that there is such a contraction at the case-openings as to produce a huddling of steam, the testimony of Mr. Forbes on this point (p. 214–215) relating solely and

indefinitely to the modified experimental exhibit, "Defendant's Kunkle valve B, No. 1"; *third*, that the experiments tried and demonstrations made show conclusively that the forces used in the operation of the valve are impact and suction, which are distinguished from huddling or backing up and compression just as a pull is distinguished from a push. It therefore again follows that Kunkle does not use either the means or the method claimed for Richardson, but on the contrary, other means and other methods, which are inconsistent with the use of the former.

But *fourth*, if, for the sake of the argument, it be conceded that Kunkle dispenses with the pendant flange or lip c, c, and attains the desired result by other means and methods, and if, even, it be violently conceded that as contradistinguished from Richardson, he uses impact and suction, and like Richardson, and as an additional or auxiliary element, he also uses, to some extent, huddling produced by a contraction at the openings of the valve-case (indeed a most violent assumption), still by a fundamental rule of patent law it is imcumbent upon complainant to show that in 1866 such a combination of means and forces was a then well-known, interchangeable, mechanical equivalent, for this purpose, of Richardson's means and methods as to which there is a total absence of any testimony whatever. As to this complainant's rely (brf. p. 39–40) upon the testimony of Mr. Hoadley, that in 1848 he knew the fact "that all turns in steam "passages caused obstruction," but it still remains that the knowledge that the best safety-valve known to this

day could be made by the combined forces of impact and suction, produced by a serpentine and constantly enlarging escape passage from the boiler through the valve to the atmosphere, was first given to the world through the Kunkle patents of 1875 and 1877. If the desperate arguments of complainant as to the openings in the valve-case were true in fact, yet complainant must fail on account of an utter absence of proof that the mechanism charged was, at the date of the patent sued upon, the well-known mechanical equivalent of the means patented for the purpose intended.

WATERMAN REISSUE.

The third contention for the Appellee is that by reason of Richardson's purchase of the Waterman patent of 1853, and of his subscribing, in 1867, the reissue thereof he abandoned the claim of his 1866 patent and he and his assignees are estopped from claiming thereunder.

What the firm of Geo. W. Richardson and Co. did or did not do with reference to the details of their manufacture and to their dealings with the public is not here in point and the testimony relating thereto contained in the stipulation at the end of the record as being what Waterman would swear to if alive, is for the most part immaterial.

A Waterman valve made (p. 120) from Waterman's original patent of 1853, and which Waterman admitted

(p. 120) was a fair representation of it, opens at the required point, 100 pounds, and closes with a reduction of only two pounds pressure. See experiment reported at pp. 125 & 126 of the record as the result, of which Mr. Hoadley says (p. 126) "the operation of this valve is "very beautiful, as good as that of any valve I ever "tried."

Waterman himself, an interested witness for plaintiff, swears, (S. 15 Cross Int. 23) that the distinguishing feature between his patent of 1853 and Richardson's of 1866, was that, as he mistakenly thought, he was not at liberty to use the direct acting spring, for, he says, "My "original valve relieved the boiler the same as his."

All the talk by Waterman about his original valve as applied to the engine "Lowell," that it was dangerous and would not work, is cunningly misleading, for it appears (S. p. 3.) that this valve was made during the first year of his employment on the Hudson River R. R., which (S. p. 2) was in 1851 or 1852, and was the first of his experimental efforts which resulted in the last part (November) of 1853 in his original patent.

The plain facts about this matter, when the evidence is all put together, are:

Waterman in 1853 showed in his patent, but did not claim, a valve which, at the very least of it, was very similar to Richardson's, and which when properly loaded would do all that Richardson's would do, but he, Waterman, mistakenly thought that he could not adopt the proper load.

On the other hand Richardson went to Waterman, no matter with what particular purpose, and Waterman said to him (S. p. 14), "I can make that (my) valve do just what yours does. It is folly for us to quarrel, for if we do there will be a dead-lock between our patents for a little more than seven years."

Richardson took advantage of the situation and transferred his claim to the older, Waterman patent, and bought that patent, "*the terms of the conveyance*" being (S. p. 7) that "I (Waterman) was to let them have my patent and obtain a re-issue *for the valve*."

Those were the days of loose re-issues, when anything clearly shown in the original patent, whether stated as a part of the original invention or not, could be claimed in the re-issue.

That this reissue of 1867 was and was intended to be for the thing which these parties had supposed was covered by the Richardson patent, plainly appears from the experiments with the original Waterman above referred to, from the attending circumstances, from the participation in the re-issue proceedings of two members of the firm of Geo. W. Richardson & Co., to-wit, Richardson himself and W. H. Poor, and from the finding of this Court in the Crosby case (Appx. p. 9, q. v.) as to what the re-issue contains.

To what is contained in that opinion in the Crosby case the following quotation (S. p. 13), from the specifications of this re-issue, which Richardson signed perfects this argument, viz: "The object which I have in view is

"to keep the pressure of the steam as near as possible "(at) the initial point of blowing, and not allow it to go "above that point and not to escape materially below it;" the second and added claim of the re-issue being upon "the concentric rim or ledge l l and the overhanging "part of the valve kk."

It may well be that, for the purpose of prolonging their monopoly before the public, the manufactured goods of this firm were stamped with the date of the Richardson and not of the Waterman patent, and that in only one license (which so far as this record shows is the only license ever granted) was the patent mentioned.

The application for the reissue was made after Waterman went into the firm (S. p. 16) and Richardson was not only aware of the proceedings (S. p. 17) but he participated as a subscribing witness in the claim then made for his benefit and pursuant to a bargain he made with Waterman.

Now the plain proposition of abandonment to the public and of equitable estoppel growing out of this is, to use the reasoning of this Court in other cases, either Richardson knew and thus acknowledged that Waterman, and not he, was the original and first inventor of the device which Richardson was then trying to put upon the market, or he then elected to base his claim upon the older Waterman patent, and that he, by his purchase from Waterman and by his signature and his participation in the re-issue proceedings in the Patent Office, said one or the other or both of these two things to the public.

PATENT OF 1869.

The claim of this patent is:

"The combination of the surface beyond the seat of "the safety valve with the means herein described for "regulating or adjusting the area of the passage for the "escape of steam substantially as and for the purpose "described."

In the light of the proof in the Crosby case that the Webster valve was an impracticable, useless contrivance, this Court in that case said, (Appx. p. 10) that by this claim Richardson was entitled to cover: "the combina- "tion with the surface of the huddling chamber, *and the* "*strictured orifice*, of a screw ring to be moved up and "down, to obstruct *such orifice* more or less, *in the man-* "*ner described.*"

I. The theory of complainant that the strictured orifice is found in the top of the case, in the Kunkle valve, and the claim, made upon the authority of this Court quoted above, that the Kunkle screw ring "*obstructs such orifice*," is, to say the least, very amusing, for these open holes or slots, cast in the top of the case, always remain constant and are never obstructed by anything. In fact we have shown that they don't even, themselves, obstruct anything.

II. That this patent is fully anticipated if construed to cover broadly screw-rings in safety valves independent of their co-operation or combination is plain for, every

man who, in 1869, was out of his teens, knows, that, for the purpose of regulating the size of any opening, a screw ring and a sliding collar with a set screw or a jam nut were the well known mechanical equivalents of each other and interchangeable, according to the convenience of the mechanic or designer ; and complainant's expert in preparing a Webster valve for the purpose of his own experiments attached the adjustable flange which produces the stricture in the Webster patent to the valve stem by screw threads and thus made of the flange a screw-ring, (p. 167).

III. If this 1869 patent be construed to cover broadly screw rings which obstruct or vary (or both) the escape aperture or apertures to the air in a safety valve, then the necessary conclusion from the most superficial reading of the Webster patent is that the former is fully anticipated. Mr. Forbes says (p. 32), that in the Webster patent a variation of the reduction of the boiler pressure is effected by reason of "making the "supplemental flange vertically adjustable upon the valve "spindle."

IV. It has been contended at Circuit, upon the authority of the above isolated quotation from the prior opinion of this Court, that Richardson under the above claim, is entitled to cover broadly, in an ordinary safety valve having a huddling chamber, *the exit of which is strictured*, the use of a screw-ring to regulate or adjust such a strictured orifice.

The answers to that proposition are:

~~First.~~ *Kunkle has not, never had, and can not have any such huddling chamber, much less any such strictured orifice.* This has already been demonstrated, requires no further argument, and is determinative of this case as to the patent of 1869.

In construction, in location, in operation and in purpose the adjustable ring of the Kunkle valve is radically opposed to the srew-ring of this patent, as clearly shown by the experiments and as stated in the record at page 197–199, as follows:

"When (in the Kunkle valves) the adjustable ring "is so set as to produce the greatest diminution of "the opening it is capable of producing, the opening "is still so large, when the valve is raised sufficiently to "discharge steam freely, that there is no real contrac- "tion and no real obstruction of the flow, for the steam "must flow out wholly, or almost wholly, against the "upper surface of the opening, little, if any, coming in "contact with the lower surface or top of the adjustable "ring.

"One evidence, to my mind, of this state of facts is "that I could not find any downward pressure at the "upper surface of the adjustable ring. Another is that "when the valve is opened in the manner I have de- "scribed, with the ring at its highest position, the open- "ing is larger at this point than through the ground- "joint, *and larger than through the intermediate chamber.* "Steam is therefore flowing out through a channel which "is nowhere enlarged and then contracted, but through a

"channel which is enlarged from within outward. It is "obstructed, it is true, by having twice to change its "course, and these obstructions increase the pressure. "Still the pressure is a diminishing pressure from within "outward,"

Experimentally and as a *tour de force* a modified Kunkle valve (exhibit B No. 1) was made and introduced by defendant, and in that valve, by also changing the spring, a stricture could be formed; but, the record continues, (p. 199) that is "not characteristic of the Kunkle "valve. But, as I stated, nothing of the kind can be "found in the other exhibits. *Before the rings could be "raised high enough to produce a stricture, they were en-"tirely unscrewed from their seats.*"

His Honor Judge Blodgett found the facts of the case as follows:

"The defendant's valve shows an extended area of "the valve-head, so as to form a flange, and an extension "of the valve-seat upward so as to form a ring encircling "and reaching above the extended valve-head, so that "the steam as it escapes through the ground-joint im-"pinges upon the flange of the valve-head, and by its im-"pact furnishes an auxiliary lift to aid in raising the valve "still higher. The Kunkle valve shows also a screw "ring attached to the valve seat, and so arranged as to "be movable up and down, thereby controlling, to some "extent, the direction of the escaping steam and causing "it to impinge more or less directly upon the flange of "the valve head." * * * "Webster, it seems to me,

" shows not only a stricture but the element of adjustabil-
" ity is clearly shown by the provision for raising or low-
" ering the auxiliary plate or flange upon the spindle of
" the valve so as to increase or diminish the opening for
" the escape of the steam from beneath the extended area
" of the supplemental flange." * * * " It is true
" the defendant uses a screw ring in his valve, and that
" Richardson in his patent of 1869 shows a screw ring,
" but the screw ring shown in defendant's device is not,
" in its function nor relation to the operation of the de-
" fendant's patent, the same as the screw ring of the com-
" plainant's device of 1869. The complainant's screw
" ring was intended specifically to operate as a stricture,
" or to regulate the size of the opening for the escape of
" the steam, a duty which is not performed by the defend-
" ant's ring. The idea of so regulating even the size of
" the stricture by a moveable plate is older than Rich-
" ardson's invention and was public property when his
" invention was made."

The necessary conclusions are: First. That this Court has limited this patent to a screw ring *which adjusts the size of the opening of the huddling chamber*, which opening forms a stricture which is always smaller than the opening at the ground-joint, for, such limitations are clearly made necessary by the prior art and are as clearly included in the specifications of this patent and in the opinion of this Court, and Second. That, whether Mr. Forbes' theory of the location of the supposed stricture in the defendant's valves be true or not, said valves do not have any such stricture nor any screw ring which regu-

lates the size of any such aperture of the huddling chamber.

V. While the above conclusions, based upon matters of fact, are indisputable, there are other legal reasons which also necessitate the conclusion that this patent of 1869 is not infringed.

On the authority of *Wicke* v. *Ostrum*, 103 U. S., 461, (which is the leading case for the doctrine there stated in the opinion delivered by His Honor, the Chief Justice,) it matters not, for any purpose of this case, whether Richardson was or was not the first to utilize a screw-ring in a safety-valve, for he is by law limited, in the proper construction of the claim of his patent, to *all* the means therein described which are *necessary* to attain the object of his invention, and "the mechanical "equivalents of his several elements known at the time "of his invention if used in the same combination." This necessarily follows from the fundamental doctrine that no one can properly claim all ways of accomplishing any one object, which doctrine, since the decision in 1853 of *O'Reilly* v. *Morse*, has been, by this Court, most rigorously enforced.

What are the necessary co-operating elements of this 1869 patent contributing, in the manner described, to the object of the alleged invention?

The only discernable drawing, in the record, of this patent is opposite page 30. From that and from the specifications of this patent (pp. 68 and 69) we learn

that, first, the alternate construction of the patent of 1866, is adopted in which the pendant flange or lip is within the extended valve-seat, and there forms a stricture; or, as stated in the specifications, "the upper sur- "face of the valve-seat, *a*, is extended all around * * "the plane of the upper edge of which, when the valve "is closed, extends a short distance above the plane of "the lower edge of the flange, *n*, of the cap"—and this (1) *variable stricture* remains the micrometer of the valve; secondly we find that the column of the escaping steam is divided, one part passing this stricture and another, passing by and around the studs, *r*, *r*, which hold the cap plate to the valve-head, goes through an auxiliary (2) central passage to a back door or second orifice formed between and by (3) the adjustable screw-ring, *u* (v in the drawing), and (4) "the disk-like pro- "jection, *f*, on the valve-rod," which "extends over the "said central aperture, *t*, and at such an elevation that "the upper edge of the adjustable ring can be set in "contact with it or let down so far below it as to leave "sufficient space for the escape of steam."

At page 69 of the record the specifications of this patent say that the closing action of the valve "will "depend upon *the distance between the outer periphery of* "*the flange, n, and the inner periphery of the projecting* "*rim, q.* To render this adjustable, the area of the "aperture for the escape of steam beyond the valve- "seat must be adjustable. This is effected by the rais- "ing or the lowering of the ring, *u*."

It is very difficult to see how the distance between the outer surface of *n* and the inner surface of *q* is regulated by raising or lowering the ring *u*. But, supposing the statement to be true and waiving, for the present, the question of the insufficiency of the specifications and the indistinctness and uncertainty of this claim, we find, that, as to the thing shown in the drawings and lettered in the specifications, at least, the above numbered four elements, namely, the old stricture, the central auxiliary passage, the adjustable screw-ring, and the disk-like projection are absolutely necessary and essential elements in both the construction and the operation of that clumsy, inconvenient and expensive thing.

Now, in the Kunkle valve no single one of these elements, and no mechanical equivalent for one of them, is present. The defendant has no stricture, has no central passage, has no divided column of steam, has no back door or auxiliary adjustable stricture, and he has no disk-like projection. He has *a* screw-ring, but it is not located or combined, and does not operate as does this screw-ring, for in the Kunkle valves there is no huddling, the outlet to the atmosphere being larger than the inlet from the boiler, the single serpentine passage between them constantly enlarges from within outwards, and the valve depends both for its sufficient opening and for its prompt closing, not upon huddling or compression, but upon the combined forces of impact and suction.

VI. In addition to the misleading and wholly unsatisfactory character of the specifications just named: The claim of this patent is for the combination of the sur-

face, etc., "with *the means herein described* for regulating," etc. Two distinct and inconsistent means, which are not interchangeable and can not have common equivalents, one of which is not shown in the drawings but is described in the specifications (p. 69, at side paging 143), are described, and it is utterly impossible for the public to tell from reading this patent what "the means" patented are. The law prescribing as a condition precedent to the grant of a patent (U. S. Rev. St. Sec. 4888) "that "he shall particularly point out and distinctly claim the "part, improvement or combination which he claims as "his invention or discovery" was in this case grossly violated, and for that reason this patent should be decreed to be invalid and void.

Brooks v. *Fisk*, 15 How. 212.
Merrill v. *Yeomans*, 94 U. S. 568.

The fourth, fifth and sixth contentions of appellee seem, thus, to be maintained, that, for the reason just named, this patent is void; that if valid it only covers a special combination, and if given a broader construction is anticipated by the Webster patent; and, finally, that, upon any possible, proper construction, it, like the patent of 1866, is not infringed.

Respectfully submitted,

J. H. RAYMOND,

Solicitor and of Counsel for Appellee,

HONORE BUILDINGS,
CHICAGO, April, 1886.

APPENDIX

A.

OPINION OF THE SUPREME COURT, BY MR. JUSTICE BLATCHFORD.

[JANUARY 19TH, 1885.]

—IN—

CONSOLIDATED SAFETY VALVE CO.

vs.

CROSBY STEAM GAUGE & VALVE CO.

Omitting the specifications of the patents and the description of the then defendant's device, and with some italics for convenience of reference.

The view taken by the Circuit Court, in dismissing the bills, was, that some valves had been made before 1866, which embodied the same general principle as Richardson's, and were of some value, operating through the expansive power of steam exerted upon an additional chamber outside of the ground-joint; and that what Richardson did was to so regulate the action of the chamber outside of the ground-joint, by a crack or opening between the lip of the valve and its main body, that the steam would be confined or huddled, when it sought to escape from the chamber, and so the valve would be held up just long enough, and could fall rapidly before too much steam was lost. But, the case went off on the question of infringement, and the Circuit Court found, that while the defendant's valve employed an additional surface to lift the valve as soon as it began to blow, and

the pressure was regulated in part by a stricture, it differed from the plaintiff's, in that the additional area was not outside of the ground-joint, but inside, and was not acted on independently of the valve itself, but was a part of it, and the escaping steam did not act at all by impact, but wholly by expansion. The conclusion was, that, as Richardson was not the first to apply the idea of an additional area or of a stricture, he could not enjoin a valve which resembled his only in adopting such general ideas, and that his claims did not cover a valve having the mode of operation of the defendant's.

Edward H. Ashcroft, as assignee of William Naylor, obtained reissued letters-patent of the United States, No. 3,727, dated November 9th, 1869, on the surrender of letters-patent No. 58,962, issued to said Naylor, October 16th, 1866, for an improvement in safety-valves. Ashcroft brought a suit in equity, in the Circuit Court of the United States for the District of Massachusetts, against the Boston and Lowell Railroad Company, for the infringement of reissue No. 3,727. The infringement consisted in the use of valves constructed according to the patent of 1866 to Richardson. The Court dismissed the bill, (5 *Off. Gaz.*, 725, and 1 *Holmes*, 366, and 1 *Bann. & A.*, 215,) and, on an appeal to this Court, by the plaintiff, the decree was affirmed. (97 U S., 189.) In view of an English patent, No. 1,038, granted to Charles Beyer, April 25th, 1863, *it was held by this Court, that Naylor was not the first person who devised means for using the recoil action of steam to assist in lifting the valve, or who invented the combination, in a spring safety-valve, of an overhanging downward curved lip, with an annular recess surrounding the valve-seat, into which steam is deflected as it issues between the valve and its seat.* In speaking of the *invention of Richardson*, as described in his patent of 1866, this Court said: "His invention, as as he describes it, *consists in increasing the area of the head of the common safety-valve outside of its ground-joint, and terminating it in such a way* as to form an increased resisting surface, against which the steam escaping from the generator shall act with additional force, after lifting the valve from its seat at the ground-joint, and so, by over-

coming the rapidly increasing resistance of the spring or scales, will insure the lifting of the valve still higher, thus affording so certain and free a passage for the steam to escape as effectually to prevent the bursting of the boiler or generator, even when the steam is shut off and the damper left open. Safty-valves previously in use were not suited to accomplish what was desired, which was to open for the purpose of relieving the boiler, and then to close again at a pressure as nearly as possible equal to that at which the valve opened. Sufficient appears to show that Richardson so far accomplished that purpose as to invent a valve which would open at the given pressure to which it was adjusted, and relieve the boiler, and then close again when the pressure was reduced about two and one-half pounds to the inch, even when the pressure in the generater was one hundred pounds to the same extent of surface, which made it, in practice, a useful spring safety-valve, as proved by the fact that it went almost immediately into general use. . . . . When the valve opens the steam expands and flows into the annular space around the ground-joint. Its free escape, which might otherwise be too free, is prevented by a stricture or narrow space formed by the outer edge of the lip and the valve-seat. By these means, the steam escaping from the valve is made to act, by its expansive force, upon an additional area outside of the device, as ordinarily constructed, to assist in raising the valve." On these views, it was held by this Court, that, although important functions, not very dissimilar in the effect produced, were performed by the two valves there in controversy, the means used and the mode of operation were substantially different in material respects.

In the present case, the defendant has introduced in evidence the before-named English patents to Ritchie, Webster and Hartley, and the English patent to William Naylor, No. 1,830, granted July 1st, 1863; and also letters-patent of the United States, No. 10,243, granted to Henry Waterman, November 15th, 1853, and the reissue of the same, No. 2,675, granted to him, July, 9th, 1867. In view of all these patents, and of the state of the art, it appears that Richardson was the first person who

described and introduced into use a safety-valve which, while it automatically relieved the pressure of steam in the boiler, did not, in effecting that result, reduce the pressure to such an extent as to make the use of the relieving apparatus practically impossible, because of the expenditure of time and fuel necessary to bring up the steam again to the proper working standard. His valve, while it automatically gives relief before the pressure becomes dangerously great, according to the point at which the valve is set to blow off, operates so as to automatically arrest with promptness the reduction of pressure when the boiler is relieved. His patent of 1866 gave a moderate range of pressure, as the result of the proportions there specified, and his patent of 1869 furnished a means of regulating that range of pressure, by a screw ring, within those narrow limits which are essential in the use of so subtle an agent as steam.

In regard to all of the above patents, adduced against Richardson's patent of 1866, it may be generally said, that they never were, in their day, and before the date of that patent, or of Richardson's invention, known or recognized as producing any such result as his apparatus of that patent produces, as above defined. Likenesses in them, in physical structure, to the apparatus of Richardson, in important particulars, may be pointed out, but it is only as the anatomy of a corpse resembles that of the living being. *The prior structures never effected the kind of result attained by Richardson's apparatus, because they lacked the thing which gave success. They did not have the retarding stricture which gave the lifting opportunity to the huddled stream, combined with the quick falling of the valve after relief had come.* Taught by Richardson, and by the use of his apparatus, it is not difficult for skilled mechanics to take the prior structures and so arrange and use them as to produce more or less of the beneficial results first made known by Richardson; but, prior to 1866, though these old patents and their descriptions were accessible, no valve was made producing any such results. Richardson's patent of 1866 states that the addition to the head of the valve terminates in an annular lip, which fits loosely around the valve-seat, and is sep-

arated from it by about 1-64th of an inch for an ordinary spring, and a less space for a strong spring, and a greater space for a weak spring, forming an annular chamber, and regulating the escape of the steam; that the steam, when the valve is lifted, passes beyond the valve-seat, and into the annular chamber, and acts against the increased surface of the valve-head, and thus overcomes the increasing resistance of the spring due to its compression, and lifts the valve higher, and the steam escapes freely into the open air, until the pressure is sufficiently reduced, when the spring immediately closes the valve. It is not shown that, before 1866, any known valve produced this result. On the contrary, Richardson testifies, that, for about twenty years before 1866, he was acquainted with safety-valves in practical use, by working in the locomotive repair-shops of railroad companies, part of the time as foreman, and as a locomotive engineer, and that he never, before his invention, knew, in practical use, or on sale, of any spring loaded safety-valve, capable of opening to relieve the boiler when the working pressure was exceeded, and of automatically closing with a small loss of working pressure. He also says that he was in England, for about four months, in 1873, bringing his valve to the notice of officials in the shops of some of the largest railroad companies, (his valve being one especially useful on locomotive engines on railroads;) that, while he was in England, he found no man who professed to be acquainted with, or to have heard of, a safety-valve which would automatically open and relieve the boiler at a predetermined working pressure, and automatically close when such working pressure had been slightly reduced, or who admitted that such a valve could be made until he had seen Richardson's valve work; that the master mechanics at the shops named did not believe he could make a valve close within 25 pounds of the blowing-off point; that he showed them the working of his valve with no excess beyond working pressure, and with but from 3 to 5 pounds reduction from a pressure of 130 pounds per square inch in the boiler; that he did not hear, in England, of any of the Ritchie, Webster or Hartley valves, but heard the Naylor valve blow, and that, when

it blew, the steam rose several pounds above the point where it commenced to blow, and it did not close promptly, tightly or suddenly. There is no evidence to contradict or vary the effect of this testimony.

Thomas Adams, of Manchester, England, who has spent a lifetime in the manufacture and practical working of safety-valves, testifies, that the Ritchie and Webster valves have never been in use practically in England, and the Hartley only in two or three cases, when it was a failure; that he himself has made and applied, in England, about 15,000 of Richardson's valves; that, if loaded at 120 pounds per square inch, his valve returns to its seat with a very small loss of pressure; that the Beyer valve, loaded at 120 pounds, reduces the pressure 30 pounds, before returning to its seat; and that Naylor's has been superseded by Richardson's.

It appears to have been easy enough to make a safety-valve which would relieve the boiler, but the problem was to make one which, while it opened with increasing power in the steam against the increasing resistance of a spring, would close suddenly and not gradually, by the pressure of the same spring against the steam. This was a problem of the reconciliation of antagonisms, which so often recurs in mechanics, and without which practically successful results are not attained. *What was needed was a narrow stricture*, to hold back the escaping steam and secure its expansive force inside of the lip, and thus aid the direct pressure of the steam from the boiler, in lifting the valve against the increasing tension of the spring, with the result, that, after only a small, but a sufficient, reduction in the boiler pressure, the compressed spring would, by its very compression, obtain the mastery and close the valve quickly. This problem was solved by Richardson and never before. His patent of 1869 describes the arrangement and operation of the whole apparatus, with the adjustable ring, thus: When the pressure of the steam lifts the valve, the steam acts against the surface of an annular space between the bevel of the valve-seat and the downward projecting flange of the cap-plate, to assist in holding up the valve against the increasing resistance of the spring. *The aperture between*

the valve and its seat is always greater than that between the flange and the upward projecting rim, and thus the steam in the annular space assists in holding up the valve till the boiler pressure falls below that at which the valve opened. *The difference between the closing pressure and the opening pressure depends on the distance between the flange and the rim.* There is a central aperture in the cap, through which the steam escapes when the valve is lifted, which is surrounded by a projecting cylindrical flange, threaded on the outside, to which is fitted a threaded ring, which can be turned up or down, and secured by a set screw. By this means, the area of the aperture for the escape of steam beyond the valve-seat is adjustable, the space being largest when the ring is down and smallest when the ring is up.

Ritchie's patent, in speaking of his valve, says: "This valve is weighted by a helical spring *i* (shown at Figure 2) of sufficient power according to the required pressure of the steam; and, when it is intended to be used as a reserve safety-valve, I place the spring around that part of the stem below the valve, that is to say, within the boiler, as shown at Figure 2. The advantage of this form of construction of valve over the ordinary valve is as follows: As soon as the pressure of the steam raises the valve from its seat, the flange *h*, being exposed to the pressure of the steam, presents an increased surface, which compensates for the increasing resistance of the helical spring *i*, until the valve has been raised to a height equal to the area of the steam-way, when it allows the steam or vapor to escape freely." In an article in "The Artizan," published in England, in July, 1858, signed by Ritchie, and referring to his patent of 1848, it is said of his valve: "The top area being made double that of the under side or steam-way, such a valve would quickly reduce the pressure in the boiler to half that at which the valve lifted; and so, also, of other proportions. Hence it is chiefly suited for a reserved valve." This shows the existence of the very evil which Richardson remedied. Ritchie's patent and publication say nothing about any stricture.

The evidence in the present case shows satisfactorily,

that valves made in conformity with the measurements of the drawing of Ritchie's patent do, in practice, reduce the pressure in the boiler to such an extent, after that pressure is properly relieved,and before they close,as to involve great loss of time and consumption of fuel before the initial pressure is restored. The experimental valves produced by the defendant as structures made according to Ritchie's patent vary from the dimensions of his drawing, and the variations are those which result from the instructions given by Richardson in his patents. Richie gives no information how to make a valve work at a predetermined pressure, or how to make it work with a small range of difference between the opening and closing pressures, or how to proportion the strength of the spring and the size of the stricture to each other. The same thing is true of the Webster and the Hartley patents.

The Webster patent shows a huddling chamber and a stricture. But the evidence shows that valves made with the proportions shown in the drawings of Webster work with so large a loss of boiler pressure, before closing, as to be practically and economically worthless. Webster's patent describes a means of making the area for the eseape of steam adjustable, consisting in adjusting up and down, on a smooth valve-stem, a sliding collar or flange, and fixing it in place by a set-screw. But it does not show the screw-ring of Richardson, with its minute delicacy of adjustment and action.

Nothing further need be said as to the Hartley valve or the Beyer valve.

The original patent to Waterman was issued in 1853. His attention had been turned to the subject of safety-valves for locomotive engines. He invented what is described in that patent, but he testifies that, before 1866, he never saw a safety-valve capable of keeping the pressure at a point not above working pressure, and of relieving the boiler with but a small loss of pressure; that his valve would let the steam down about 15 pounds, and was not practical for an ordinary locomotive; and that the Richardson valve, when introduced, went at once into general use. The Waterman valve had a supplemental surface, on which the steam acted to aid in the raising of the valve;

and this was shown in the drawing of Waterman's original patent, but the specification did not describe it. Waterman's original patent did not show the use of a spring, and prior to its reissue his valve had not been made with a spring. After Richardson obtained his patent of 1866, and Waterman knew of Richardson's valve, they combined the interests in their two patents, and the reissue of Waterman's was obtained, with the co-operation of Richardson, he signing as a witness the specification of the reissue. That specification, granted in 1867, describes an overhanging part of the valve as increasing its area outside of, and beyond, the ground-joint, and a concentric rim or ledge, which directs the steam upward against such overhanging part of the valve, so that the valve is assisted in rising. The specification was drawn in view of Richardson's patent and valve, and for the purpose of making a claim, which was then made, and which was not in Waterman's original patent, to a combination of the concentric rim or ledge with the overhanging part of the valve. The specification states, that the valve and its seat are so constructed that the escaping steam will act on an increased area of the valve after it has risen from its seat, and strike the overhanging or projecting annular surface above and outside of, and beyond, the ground-joint. It also states, that a proper modification of the overhanging or projecting annular surface will modify the force of the steam; that, if such surface be large, the valve will be opened suddenly and discharge so much steam that the pressure in the boiler will be considerably reduced before the valve closes; that such surface may be made so small that but little more than the surplus steam will escape; that the success or efficiency of the valve will depend on a proper proportion between the overhanging annular surface and the concentric rim or ledge, because, if a free discharge of steam between them is allowed, the valve will not be assisted in rising, and, if the escape of steam is too small, the valve will rise too easily, and remain open too long, and the steam will be so much reduced in pressure as seriously to impair the economical and efficient action of the apparatus; and directions are given as to the sizes of the overhanging part, and of the ledge or rim, and

of the opening, for a valve of a specified diameter, acting with a specified pressure of steam. Nothing of all this was found in the specification of the original Waterman patent. It, therefore, has no effect as against Richardson's patent of 1866, to destroy the validity of that patent.

If anything which Richardson did in respect to reissuing the Waterman patent, could, in any event, affect the rights of the present plaintiff under either patent sued on, as to which we express no opinion, it is sufficient to say, that the present defendant claims, in its answers, no benefit from any action of Richardson's in respect to the Waterman patent, as operating in its favor or enuring to its benefit, as an equitable defence in these suits.

Richardson is, therefore, entitled to cover, by the claim of his patent of 1866, under the language, "a safety-valve with the circular or annular flange or lip *c c*, constructed in the manner, or substantially in the manner, shown, so as to operate as and for the purpose herein described," *a valve in which are combined an initial area, an additional area, a huddling chamber beneath the additional area, and a strictured orifice leading from the huddling chamber to the open air, the orifice being proportioned to the strength of the spring, as directed.* The direction given in the patent is, that the flange or lip is to be separated from the valve-seat by about 1-64th of an inch for an ordinary spring, with less space for a strong spring, and more space for a weak spring, to regulate the escape of the steam, as required. As matter of law, this description is sufficient, within the rule laid down in *Wood v. Underhill*, (*5 How., 1,*) and it is not shown to be insufficient, as a matter of fact.

Richardson is also entitled to cover, by the claim of his patent of 1869, under the language, "the combination of the surface beyond the seat of the safety-valve, with the means herein described, for regulating or adjusting the area of the passage for the escape of steam, substantially as and for the purpose described," *the combination with the surface of the huddling chamber, and the strictured orifice, of a screw-ring, to be moved up or down to obstruct such orifice more or less, in the manner described.*

The Richardson patents have a disc valve, an annular huddling chamber, an annular stricture at the outer extremity of the radii from the centre of the valve, an additional area which is radially beyond the disc valve, and a cylindrical steam-way. *But, before 1866, an annular form of safety-valve was well known. Such a valve necessarily requires an annular steam-way.* In the defendant's valve, Complainant's Exhibit A, the same effects in operation, are produced as in the Richardson valve, by the means described in Richardson's claims. In both structures, the valve is held to its seat by a spring, so compressed, as to keep the valve there until the pressure inside of the boiler is sufficient to move the valve against the pressure of the spring; so that the steam escapes through the ground-joint into a chamber covered by an extension of the valve, in which chamber the steam acts expansively against the extended surface, and increases the pressure in opposition to the increasing pressure of the spring and assists in opening the valve wider: this chamber, in the defendant's valve, has, at its termination, substantially the same construction as Richardson's valve, namely, a stricture, which causes the steam to act by expansive force, against the extended surface of the valve; and in both valves, after the pressure of the steam has been somewhat reduced in the boiler, the closing movement is quickened, as the valve nears its seat, in consequence of the reduced pressure of the steam on the extended surface, and the valve comes suddenly to its seat. In the Richardson valve, the valve proper is a disc, and the extended surface is an annulus surrounding the disc, while, in the defendant's valve, the valve proper is an annulus, and the extended surface is a disc inside of the annulus. But this is a mere interchange of form between the valve proper and the extended surface, within the skill of an ordinary mechanic.

There is one structural difference between the two valves, which is now to be mentioned. In the Richardson valve, all the steam which escapes into the open air escapes from the huddling chamber, through a stricture which is smaller than the aperture at the ground-joint. In the defendant's valve, the valve proper has two ground-

joints, one at the inner periphery of the annulus, and the other at its outer periphery, and only a part of the steam, namely, that which passes through one of the ground-joints, passes into the huddling chamber and then through the stricture, the other part of the steam passes directly from the boiler into the air, through the other ground-joint. But all of that part of the steam which passes into the huddling chamber and under the extended surface, passes through the constriction at the extremity of such chamber, in both valves, the difference being only one of degree, but with the same mode of operation.

* * * * * * * *

Richardson's invention brought to success what prior inventors had essayed and partly accomplished. He used some things which had been used before, but he added just that which was necessary to make the whole a practically valuable and economical apparatus. The fact that the known valves were not used, and the speedy and extensive adoption of Richardson's valve, are facts in harmony with the evidence that his valve contains just what the prior valves lacked, and go to support the conclusion at which we have arrived on the question of novelty. When the ideas necessary to success are made known, and a structure embodying those ideas is given to the world, it is easy for the skillful mechanic to vary the form by mechanism which is equivalent, and is, therefore, in a case of this kind, an infringement.

It follows, from these views, that the decrees of the Circuit Court must be reversed, and each case be remanded to that court, with a direction to enter a decree sustaining the validity of the patent sued on, and decreeing infringement, and awarding an account of profits and damages, as prayed for, and to take such further proceedings as may be proper and not inconsistent with this opinion, and with the further direction, as to the suit brought on the patent of 1869, to grant a perpetual injunction, according to the prayer of the bill.

APPENDIX B.

As to the Experimental Exhibit in this Case of the Richardson Patent of 1866.

See page 15 hereof.

I. The defendant's experimental exhibit of this patent is not only in fair, but it is in strict accordance with the patent itself, notwithstanding the mathematical criticisms raised in appellant's brief that the huddling chamber of the exhibit is constructed on *linear* dimensions.

II. The complainant's experimental exhibit of this patent of 1866, with which complainant's expert obtains successful results, is widely varied from the patent itself, and is more nearly like the old Webster patent than like the patent which it purports to represent.

I.

It is conceded that the valve with which defendant experimented, the measurements of which are given with the greatest detail on page 204 of the record, was made "exactly proportional" by linear dimensions to the Richardson patent of 1866. The criticism of complainant's counsel is that this does not give a proper cubic contents for the huddling chamber. This criticism is not well taken upon any mathematical or practical theory, but is purely captious, and its effect, whether intentional or not, is to radically deceive this court.

If the dimensions of this exhibit are "exactly proportional by linear dimensions" to the patent, it necessarily follows, by very trite geometrical laws, that all area are "exactly proportional" to the *squares* of their like dimensions; and that all cubic contents are "exactly proportional" to the *cubes* of their like dimensions; which is the thing complainant's counsel is contending for.

If diameters, which are linear dimensions, are, as they are admitted to be, "exactly proportional," then areas bounded by circles of such diameters are also exactly proportional to the squares of these diameters. The width and height of a cross section of the huddling chamber being exact linear dimensions (as admitted) the areas of such cross sections are necessarily also exactly proportioned to the squares of these like dimensions. The circumference of the huddling chamber in the middle of its width being exact and correct, it necessarily follows that the cubic contents of this chamber in the exhibit and in the patent (which is found by multiplying the area of cross section expressed in terms of a square inch by the circumference in linear inches), must be exactly proportional to the cubes of any like dimensions.

Complainant's exhibit and the patent drawing has a steam way from the boiler of 2.25 inches diameter. Defendant's exhibit has a steam-way intended to be one inch diameter (being the size of valve most frequently desired and used), but accidentally it is *one-hundredth of an inch* of less diameter, to-wit: 0.99 in., this being as close as the machinist could work.

Taking the dimensions given in this record now in point, and we find the following

Ratios.

Linear dimension first powers; areas second powers; cubic capacities third powers.

Linear dimension,	0.99	to 2.25 =	0.44 to 1.
Areas - - - -	0.9801	to 5.0625 =	0.1936 to 1.
Cubic capacities -	0.9703	to 11.3906 =	0.0852 to 1.

First as to areas: Line 5, column 6, p. 204, the area of the huddling chamber is given as 8.5012, and 8.5012 x .1936 (above ratio) = 1.6458,* which agree with the figures in column 3, line 5.

The criticism is that this dimension, for the size of

*Note.—There is a misprint in the record in this Court in line 5, column 8. It is printed 1.6548, but should be, according to the original record, 1.6458.

stricture used, is not large enough. Now, the actual and accurate measurement of this dimension (line 5, column 9, p. 204) instead of being 1.6458 is 1.7203, which actual and accurate measurement of the thing used, instead of being less is larger than the patent calls for, and is, in fact, four per cent. larger.

The patent says (p. 65) that * * "the circular or annular chamber D, D, whose transverse section, shown in the figure, *may be of any desirable form or size.*"

But the areas of cross section of the chamber D on a radial line in the patent and in defendant's exhibit are substantially proportional, the proportion for the patent being, line 10, column 8, .0079, and for the exhibit, line 10, column 9, .0080, or a difference of *one ten thousandth* of an inch. The correctness of the computations by which these proportional sizes given in said table are arrived at is not questioned and can not be.

It follows that defendants' exhibit of the Richardson patent of 1866 (0.99 in. steamway) corresponds exactly with the original Richardson drawing as to *heighth, width and area of cross-section* of the chamber D.

Second. As to cubic capacities: (See line 12, p. 204.)

The center of gravity of the area of cross section of this huddling chamber being in the middle of its width, the area of cross section in terms of a square inch multiplied by the length of a circumference at the middle of its width in linear inches will give the cubic contents.

In the 2¼ inch valve, column 6, the area of cross-section is .0408 square inches (line 10), and the circumference, corresponding to the diameter at centre of chamber D (line 9), is 3.03 x 3.1416 = 9.519 inches, and .0408 ~~squared~~ x 9.519 inches, = 0.3884 cubic inches, as in column 6, line 11.

Again, in the one inch valve, column 9, the area of cross-section is .0080 square inches (line 10), and the circumference, corresponding to the diameter at centre of chamber D (line 9), is 1.36 x 3.1416 = 4.2725 inches, and .0080 squared by x ~~3.1416~~ 4.2725 = .0342 cubic inches. But the ratio of the cubes of .0.99 inches, and 2.25 inches, is

.0825 to 1 (supra), and .3884 x .0852 = .0331—substantially the same as .0342—the difference is only 3 per cent.; and again, the capacity of the .99 inch exhibit is, in this respect, a trifle *greater* than strict proportion of cubes of like dimension demands, instead of being smaller as charged.

Complainant's counsel in the brief now filed further says that "for one-fifth of the lifting area and one-fifth of the additional area, there was provided (in defendant's exhibit, " * * a stricture of 11-25th of the area, and a "spring of the same proportionate tension," shown in the patent. This is substantially true, but is on a par with the other captious and misleading objections which have been made to every practical, fair experiment which has been tried by defendant. The criticism is not that this stricture did not retard and retain in the huddling chamber a sufficient amount of steam to raise the valve with a pop, for the valve was so raised and did pop at the proper point. This criticism, if of any merit whatever and plainly stated, is this: that the stricture in defendant's exhibit was too large for the closing operation of a valve of that size, that is, that in the closing operation it did not let out steam enough to close the valve at the proper point. If the stricture had been made rigorously to the arithmetic proportions, .207 inches wide, which is less than half as large in area as it was actually made, the reduction of pressure before closing would most manifestly have been far greater, and instead of being from 16 to 38 per cent. of the boiler pressure, would have been nearly 50 per cent.

The only two proportions suggested in this patent are, first, between the additional and the supplemental area (in which the exhibit as above shown was exactly proportional); and second, between the stricture and the spring, which proportion was also accurately and absolutely followed, the stricture in the exhibit being 1–64th of an inch wide, and the spring used being, as conceded, a spring of ordinary tension.

II.

Complainant's exhibit, with which good results were attained by complainant's expert, and which appears illustrated on page 7 of complainant's brief, is widely varied from the patent drawing of a 2¼ inch valve in the most essential feature, to-wit: "the lap," or overlap of the lip or flange, c, c, below the upper surface of the extended valve seat, E, E. This exhibit and drawing were confessed to be faulty in this regard at the hearing at Circuit and was apologized for, yet it is now again with effrontery asserted (Complainant's brief, p. 8) that it is "made exactly according to the measurement of the "patent."

This overlap, compiainant's expert witness Forbes says (p. 204, line 15, column 5) should be, according to the patent drawing, 2½ times the width of the stricture, (as 5 to 2). Now the "stricture" is, in this exhibit, 1-64 inch, which, expressed in decimals to four places, equals .0156 inches, and this multiplied by 5 and divided by 2, gives .039 inches as the "lap" or overlap $\left(\frac{.0156 \times 5}{2} = .039\right)$

Then when the valve should be so far lifted as to bring the lower edge of the lip, c, c, up level with the plane of the other wall of the "stricture," *i. e.*, the level upper surface of the extended valve-seat, the opening at the ground joint would be vertically .039 inches, and the opening at right angles to the surfaces of the ground-joint, *i. e.*, the thickness of the open space for the flow of steam out of the boiler into the huddling chamber, would be .0276 inches (.70711 x .039 = .0276), that is, 1-36 of an inch, almost equal to the well known fraction 1-32 inch, which may be measured with any pocket rule or carpenter's rule.

Put three slips of cardboard .0276 inch thick on the beveled valve-seat, and set the valve on these strips, firmly. The valve will be raised from its seat .039 inch —the true Richardson "lap"—and the lower edge of the lip, c, c, will be raised *above* the extended valve-seat 0.02 inches.

Made with Richardson's lap, .039 inches, this exhibit would reduce the pressure 30 to 40 per cent. below initial pressure before it would close.

It thus appears that defendant's embodiment is, and complainant's embodiment is not, a fair representation of the Richardson patent of 1866, and that with it the closing action of the valve can not be obtained, without the loss of working pressure being from sixteen to thirty-eight per cent.

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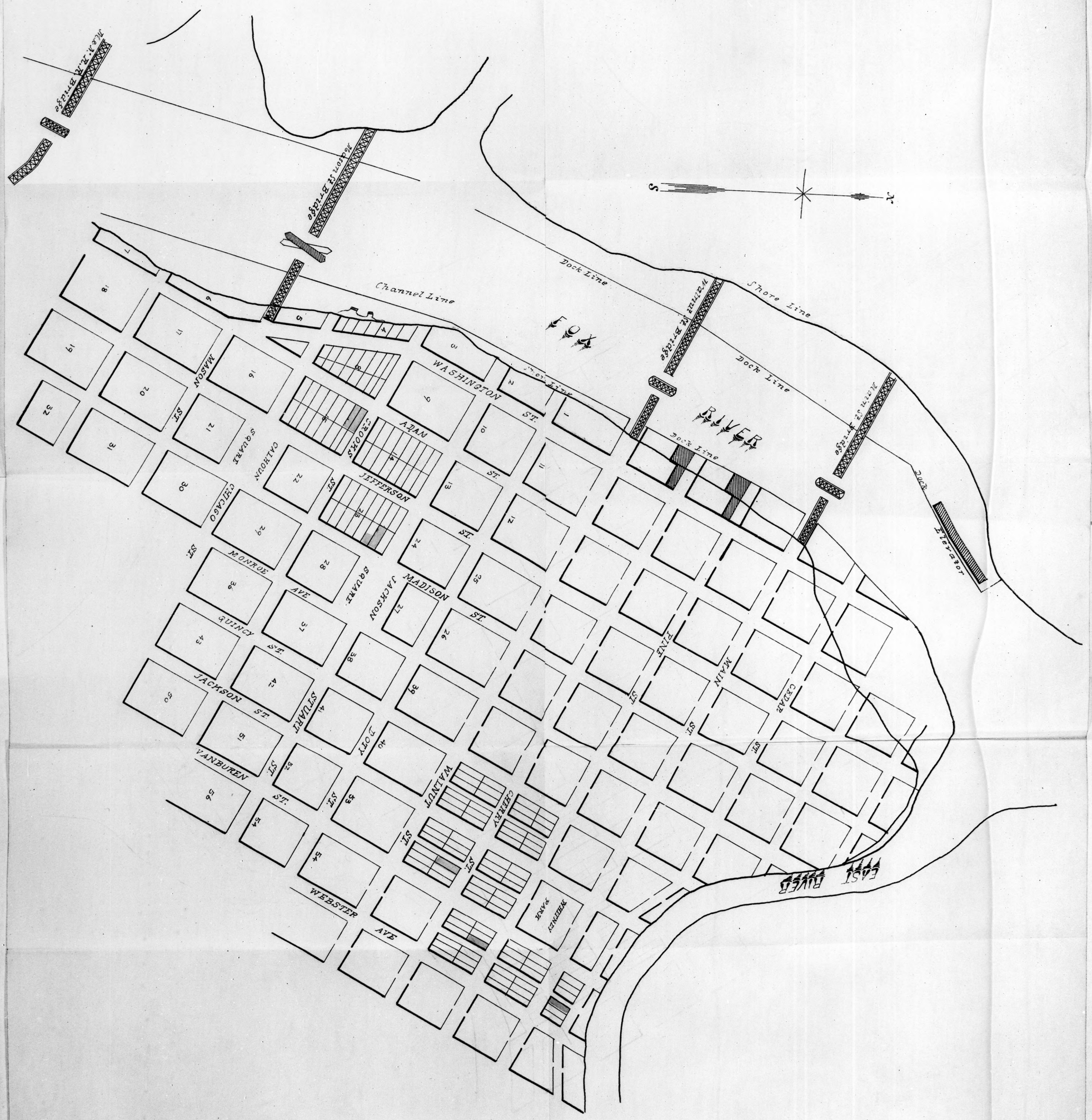

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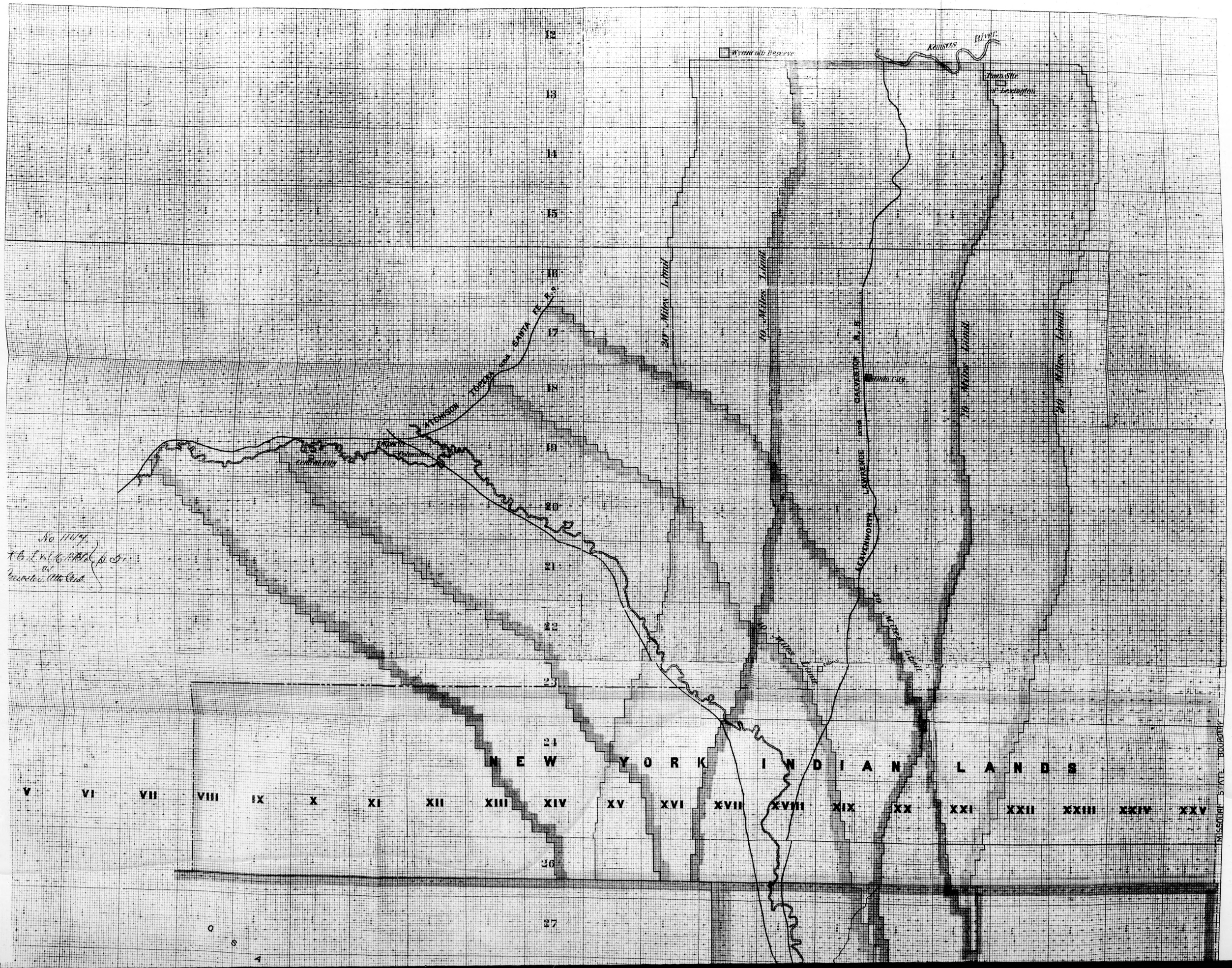

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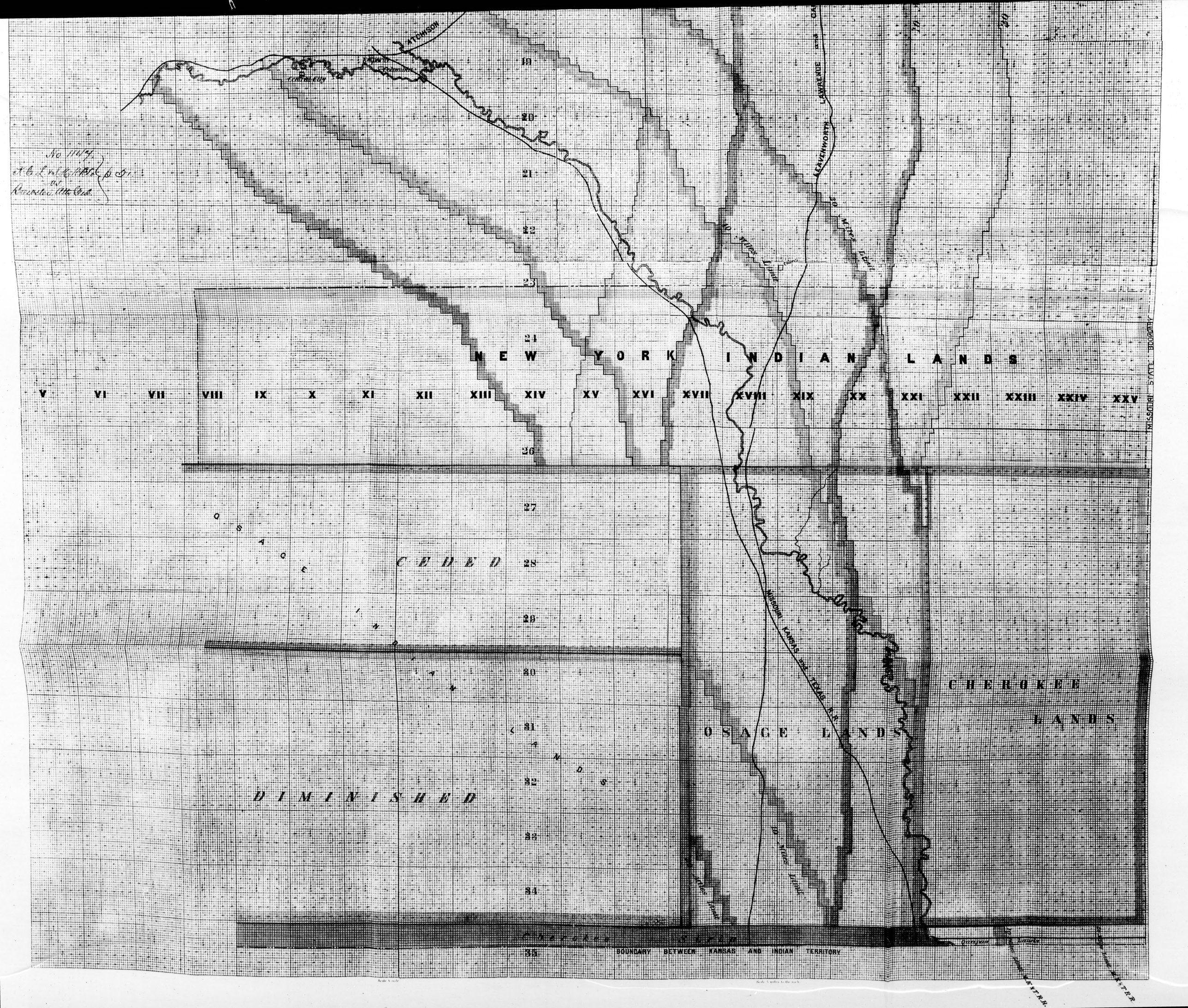

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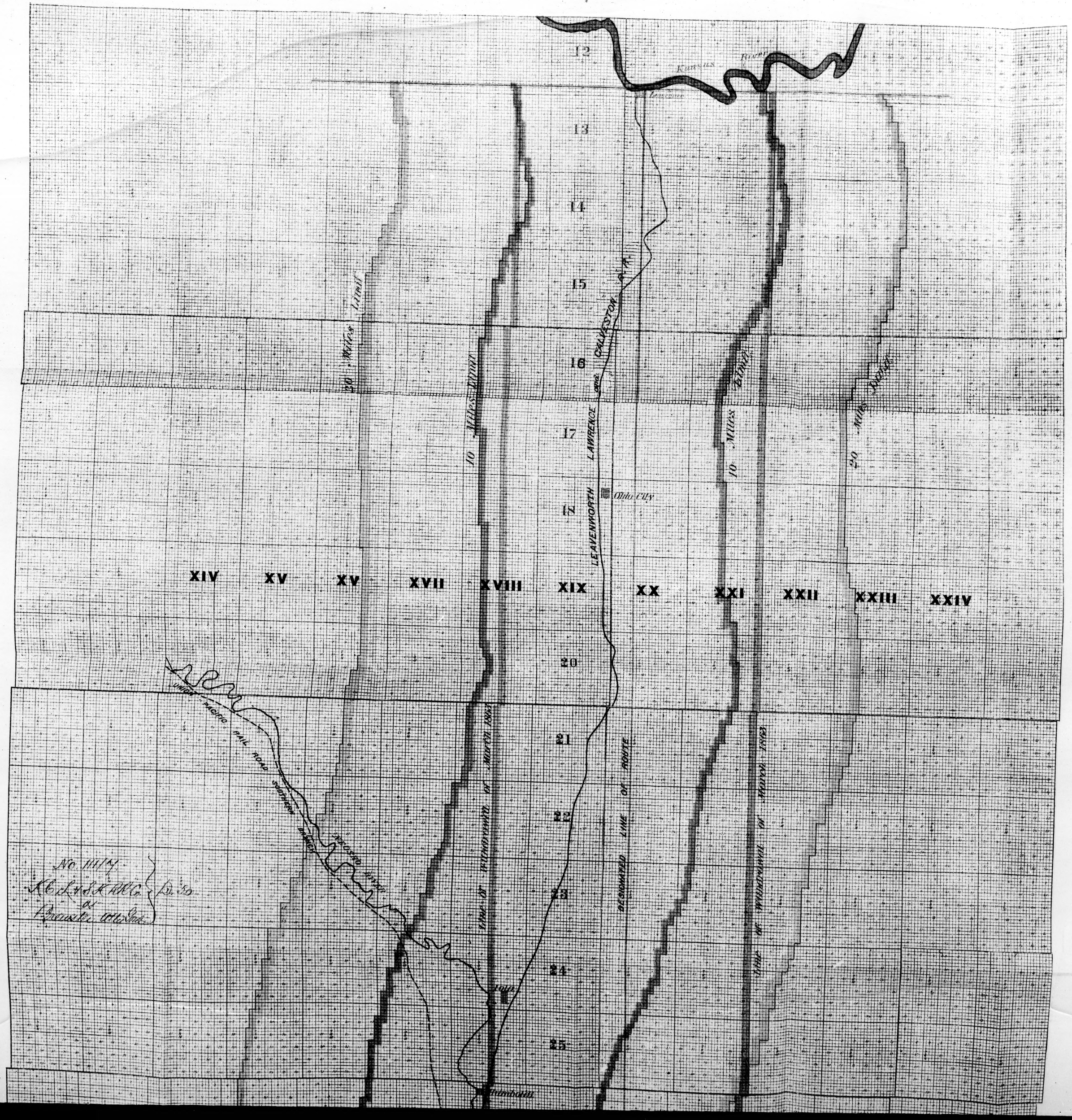

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Brewster Colt Ind.
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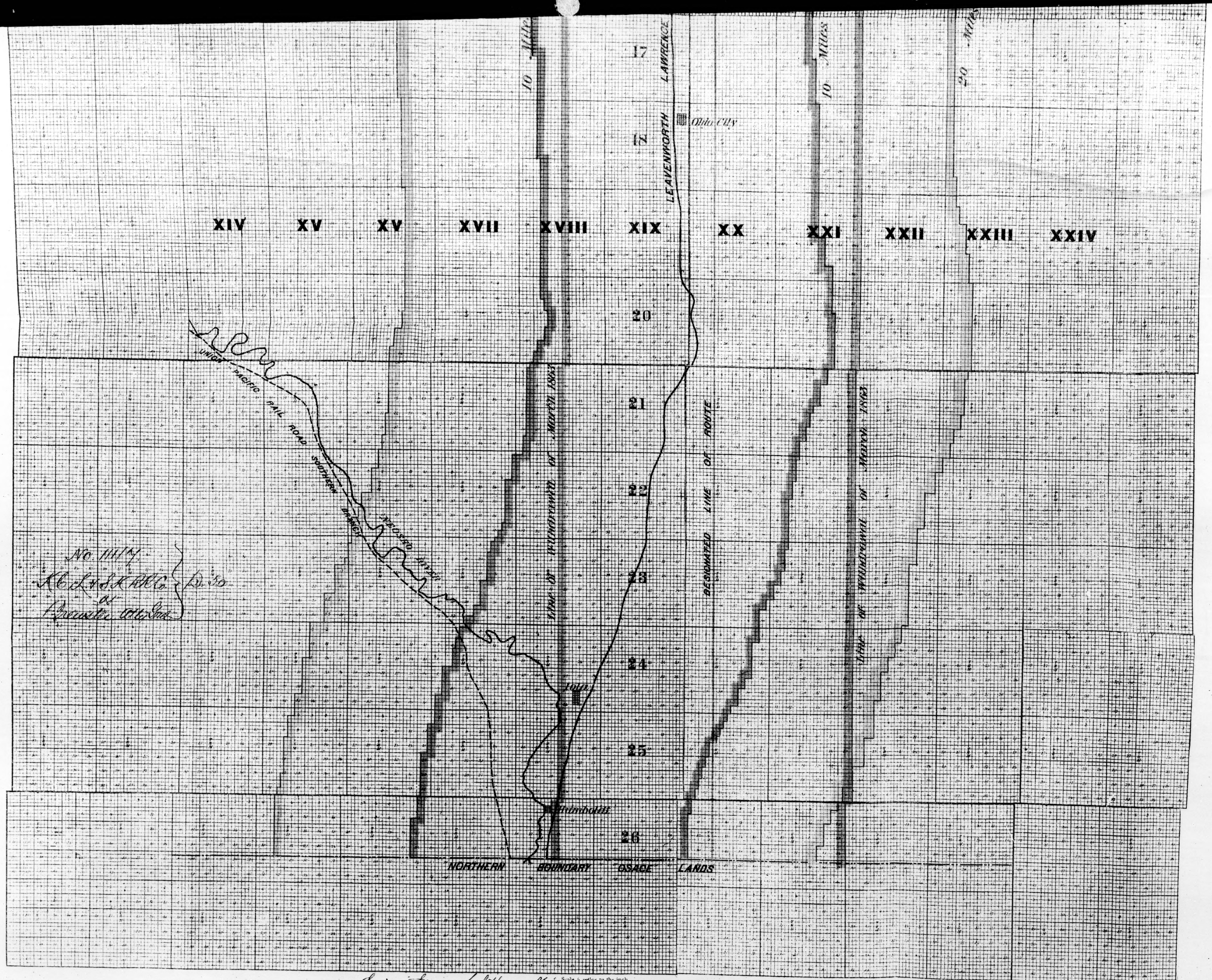

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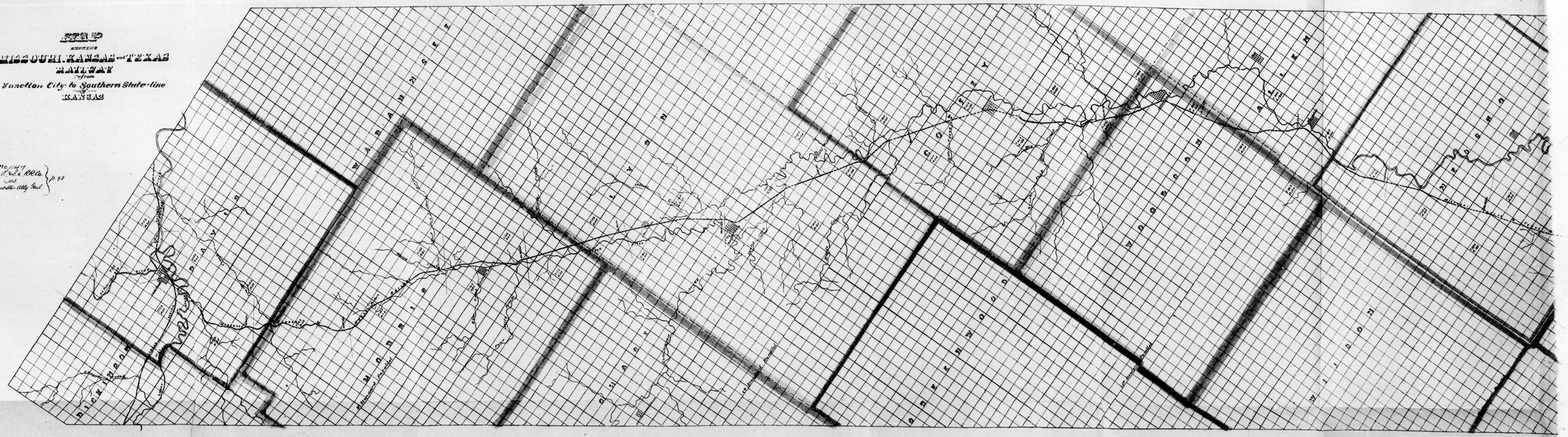
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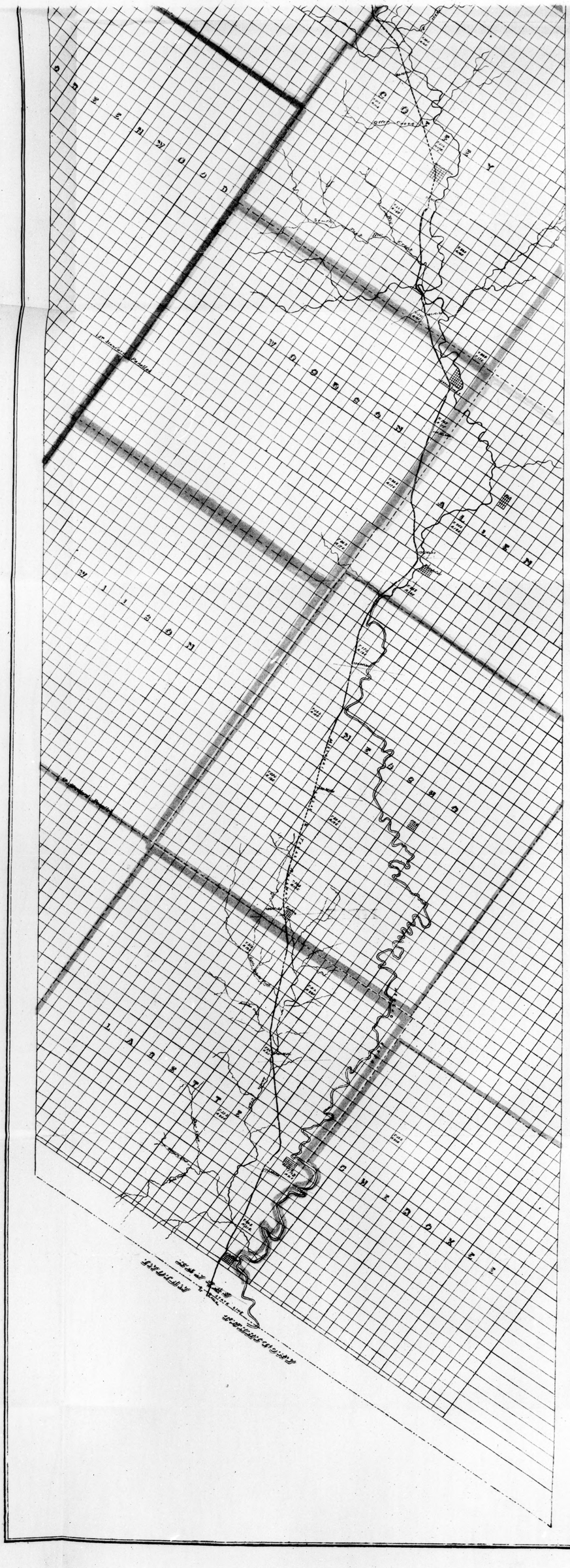
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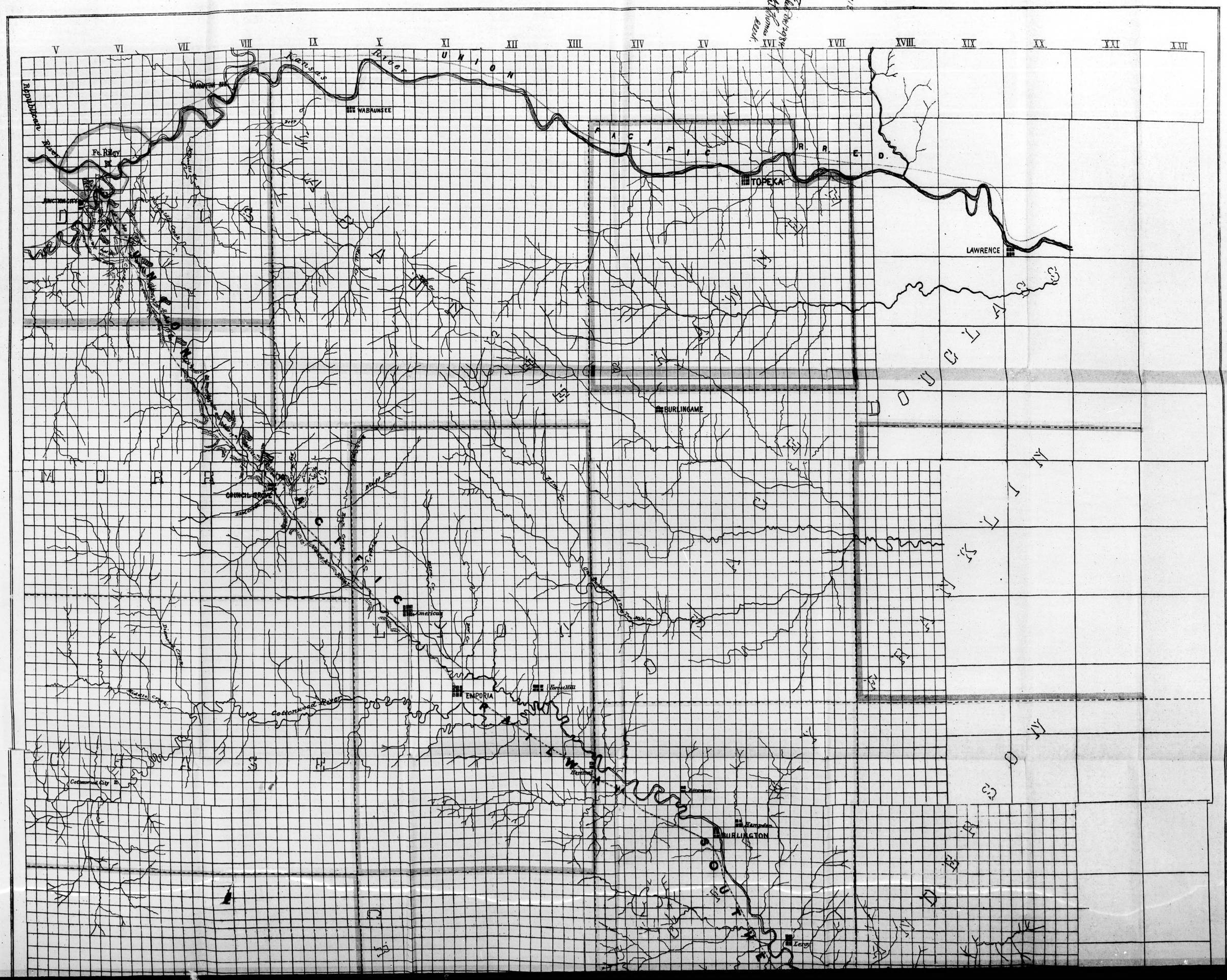

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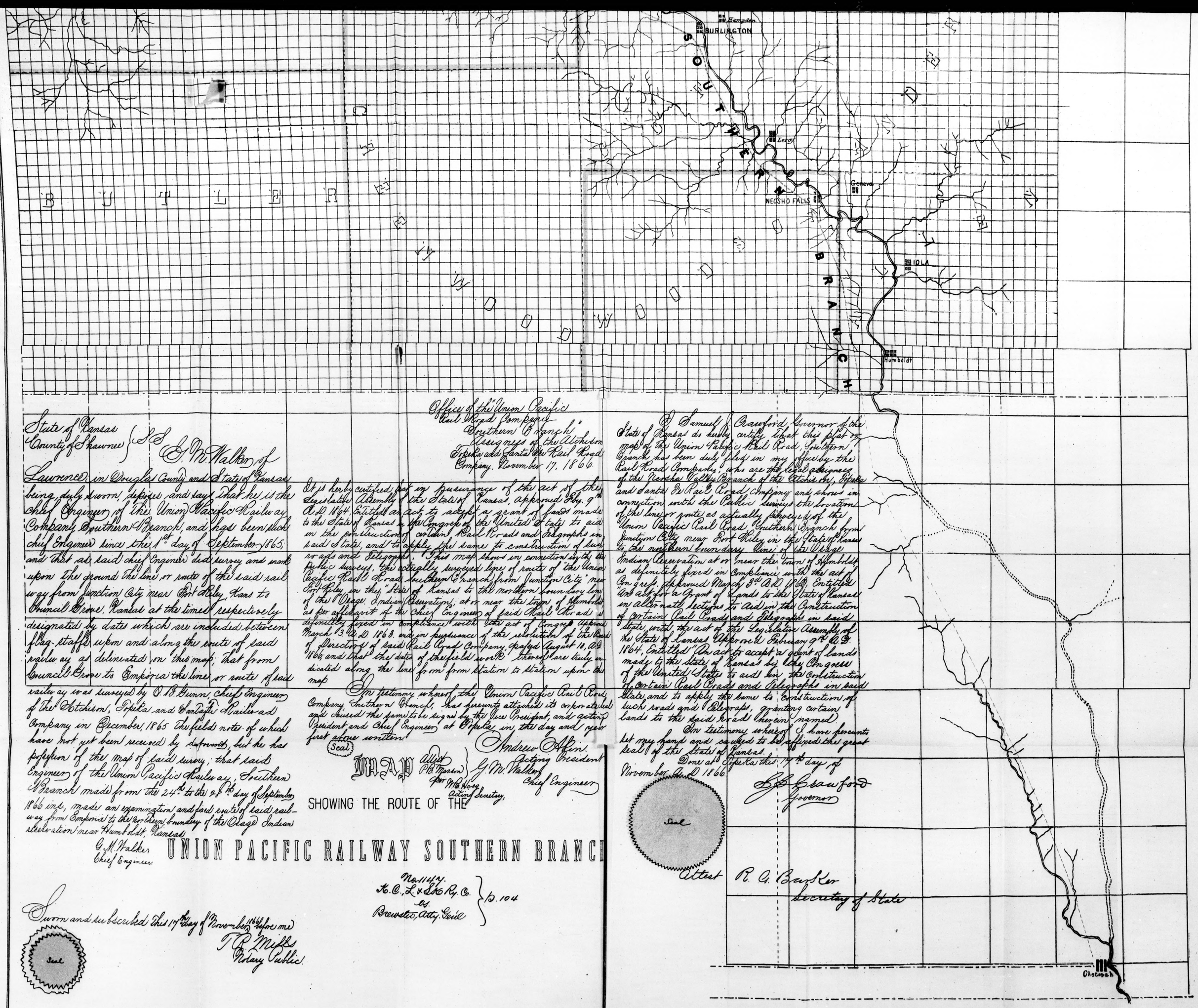


State of Kansas
County of Shawnee } S.S.

G. M. Walker of Lawrence in Douglas County and State of Kansas being duly sworn, deposes and says that he is the chief Engineer of the Union Pacific Railway Company Southern Branch, and has been such chief Engineer since the 1st day of September 1865; and that as said chief Engineer did survey and mark upon the ground the line or route of the said rail way from Junction City near Fort Riley, Kans to Council Grove, Kansas at the times respectively designated by dates which are included between flag-staffs upon and along the route of said railway as delineated on this map; that from Council Grove to Emporia the line or route of said railway was surveyed by O. B. Gunn, chief Engineer of the Atchison, Topeka and Santa Fe Railroad Company in December, 1865 the field notes of which have not yet been received by deponent, but he has possession of the map of said survey; that said Engineer of the Union Pacific Railway, Southern Branch made from the 24th to the 28th day of September 1866 ins, made an examination and fixed route of said railway from Emporia to the northern boundary of the Osage Indian reservation near Humboldt, Kansas

G. M. Walker
Chief Engineer

Office of the "Union Pacific Rail Road Company Southern Branch"
Assignees of the Atchison Topeka and Santa Fe Rail Road Company. November 17, 1866

It is hereby certified that in pursuance of the act of the Legislative Assembly of the State of Kansas, approved Feby. 9th A.D. 1864, Entitled an act to accept a grant of lands made to the State of Kansas by the Congress of the United States to aid in the construction of certain Rail Roads and Telegraphs in said State, and to apply the same to construction of such roads and Telegraphs. This map shows in connection with the public surveys, the actually surveyed line of route of "the Union Pacific Rail Road Southern Branch from Junction City" near Fort Riley in the "State of Kansas to the northern boundary line of the Osage Indian Reservation; at or near the town of Humboldt as per affidavit of the Chief Engineer of said Rail Road is definitely fixed in compliance with the act of Congress approved March 3. A.D. 1863. and in pursuance of the resolution of the Board of Directors of said Rail Road Company, passed August 10, A.D. 1866; and that the dates of the field work thereof are truly indicated along the line from from station to station upon this map

In testimony whereof the Union Pacific Rail Road Company Southern Branch, has hereunto attached its corporate seal and caused the same to be signed by the Vice President, and acting President and Chief Engineer at Topeka in the day and year first above written.

Seal

Andrew Akin
Acting President

Attest
P. B. Manson
per W. R. Hoag
Acting Secretary,

G. M. Walker
Chief Engineer

MAP

SHOWING THE ROUTE OF THE

UNION PACIFIC RAILWAY SOUTHERN BRANCH

No. 1147.
K. C., L. & S. K. Ry. Co.
vs.
Brewster, Atty. Genl
} p. 104

Sworn and subscribed this 17th day of November 1866 before me

T. R. Mills
Notary Public

Seal

I Samuel J. Crawford Governor of the State of Kansas do hereby certify that this plat or map of the Union Pacific Rail Road, Southern Branch has been duly filed in my office by the Rail Road Company, who are the legal assignees of the Neosha Valley Branch of the Atchison, Topeka and Santa Fe Rail Road Company and shows in connection with the Public surveys the location of the line or route as actually surveyed of the Union Pacific Rail Road Southern Branch from Junction City near Fort Riley in the State of Kansas to the northern boundary line of the Osage Indian Reservation at or near the town of Humboldt as definitely fixed in compliance with the act of Congress, approved March 3d A.D. 1863, Entitled "An act for a Grant of Lands to the State of Kansas in alternate Sections to Aid in the Construction of certain Rail Roads and Telegraphs in said State, with the act of the Legislative Assembly of the State of Kansas Approved February 9th A.D. 1864, Entitled "An act to accept a grant of lands made to the State of Kansas by the Congress of the United States to aid in the Construction of certain Rail Roads and Telegraphs in said State and to apply the same to construction of such roads and Telegraps, granting certain lands to the said road herein named.

In testimony whereof I have hereunto set my hand and caused to be affixed the great seal of the State of Kansas.

Done at Topeka this 17th day of November A.D. 1866.

Seal

S. J. Crawford
Governor

Attest R. C. Barker
Secretary of State

Longitude West from Greenwich

NORTHERN BOUNDARY OF KANSAS

SMITH | JEWELL | REPUBLIC | WASHINGTON | MARSHALL | NEMAHA | BROWN | DONIPHAN

OSBORNE | MITCHELL | CLOUD | CLAY | POTTAWATOMIE | JACKSON | ATCHISON

OTTAWA | LINCOLN | DAVIS | WABAUNSEE | SHAWNEE | JEFFERSON | LEAVENWORTH | WYANDOTTE

RUSSELL | DICKINSON | DOUGLAS | JOHNSON

ELLSWORTH | SALINE | MORRIS | OSAGE | FRANKLIN | MIAMI

BARTON | LYON | COFFEY | ANDERSON | LINN

RICE | MCPHERSON | MARION | CHASE

STAFFORD | RENO | HARVEY | GREENWOOD | WOODSON | ALLEN | BOURBON

PRATT | KINGMAN | BUTLER | SEDGWICK | ELK | WILSON | NEOSHO | CRAWFORD

BARBER | HARPER | SUMNER | COWLEY | CHAUTAUQUA | MONTGOMERY | LABETTE | CHEROKEE

SOUTHERN BOUNDARY OF KANSAS

Missouri River

Atchison

Leavenworth

Kansas City

Junction City

Ft. Riley

Topeka

Lawrence

Emporia

Osawatomie

Coffeyville

Kansas River

Union Pacific R.R.

Missouri Pacific R.R.

Atchison, Topeka & Santa Fe R.R.

Missouri, Kansas & Texas R.R.

Leavenworth, Lawrence & Galveston R.R.

Kansas Pacific R.R.

Missouri River, Fort Scott & Gulf R.R.

Probable Route

10 Mile Limit of Probable Route

20 Mile Limit of Probable Route

10 MILE LIMIT OF M. K. & T. R. R.

20 MILE LIMIT OF L. L. & G. R. R.

10 MILE LIMIT OF L. L. & G. R. R.

20 MILE LIMIT OF M. K. & T. R. R.

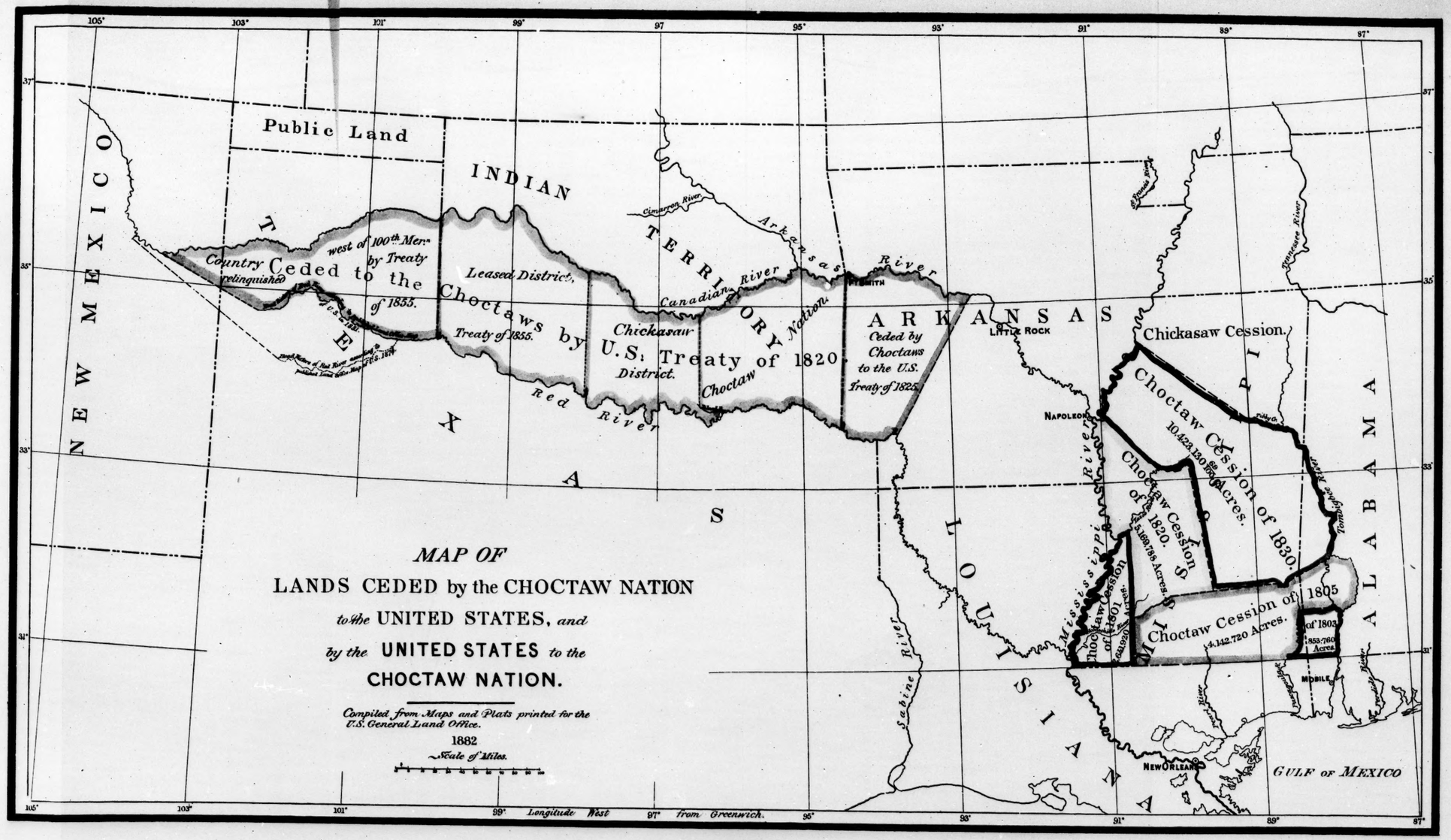
Line of Withdrawal Mar. 1863

EASTERN BOUNDARY OF KANSAS

EXPLANATIONS

- 10 Mile Limit of M. K. & T. R. R.
- 20 Mile Limit of L. L. & G. R. R.
- 10 Mile Limit of L. L. & G. R. R.
- 20 Mile Limit of M. K. & T. R. R.
- Line of Probable Route
- Line of Withdrawal of March 1863
- Location of Land in Controversy
- Unconstructed Portion of L. L. & G. R. R.

Ramsey, Millett & Hudson Mfg's, Kansas City, Mo.



MAP OF

LANDS CEDED by the CHOCTAW NATION

to the UNITED STATES, *and*

by the UNITED STATES *to the*

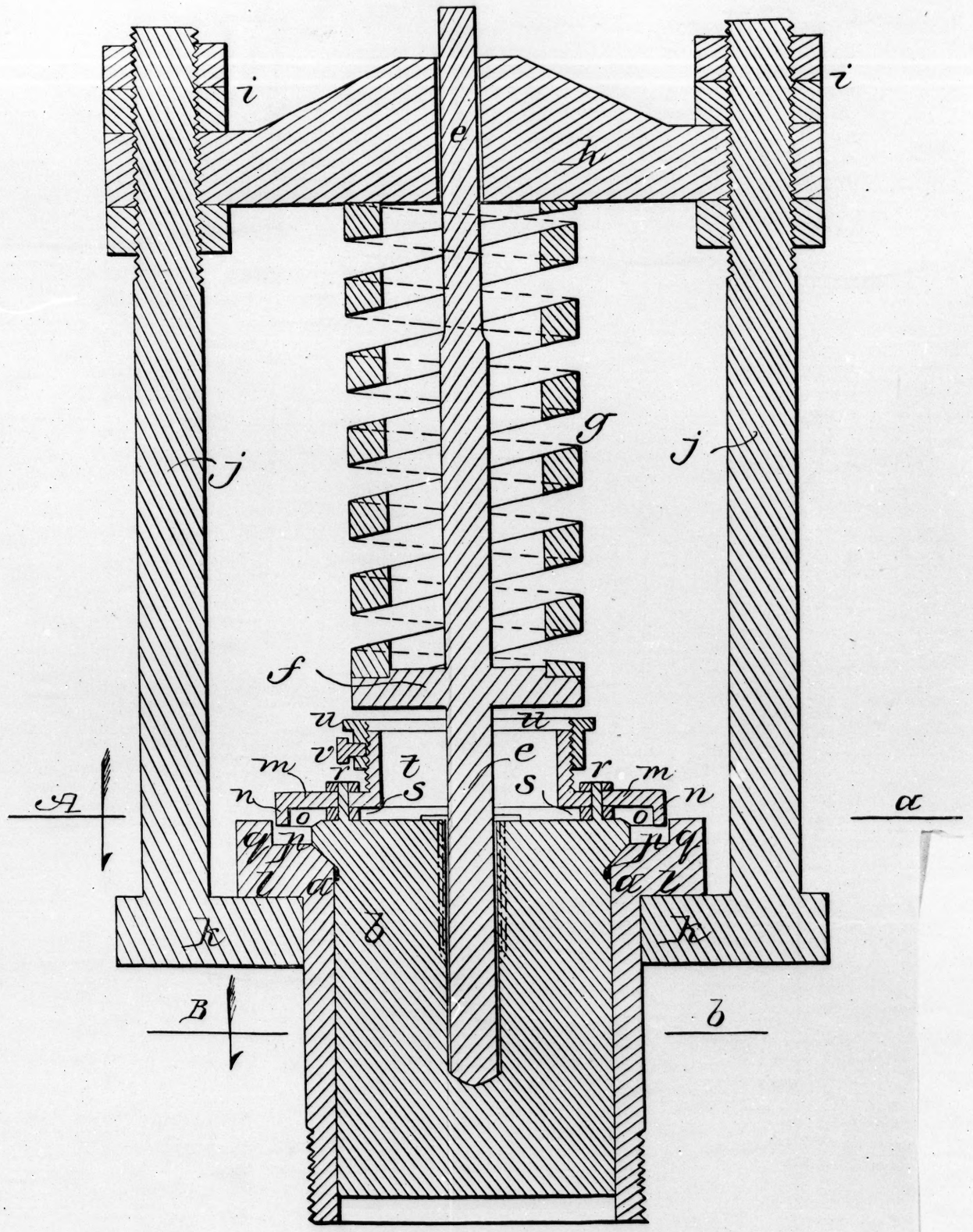
CHOCTAW NATION.

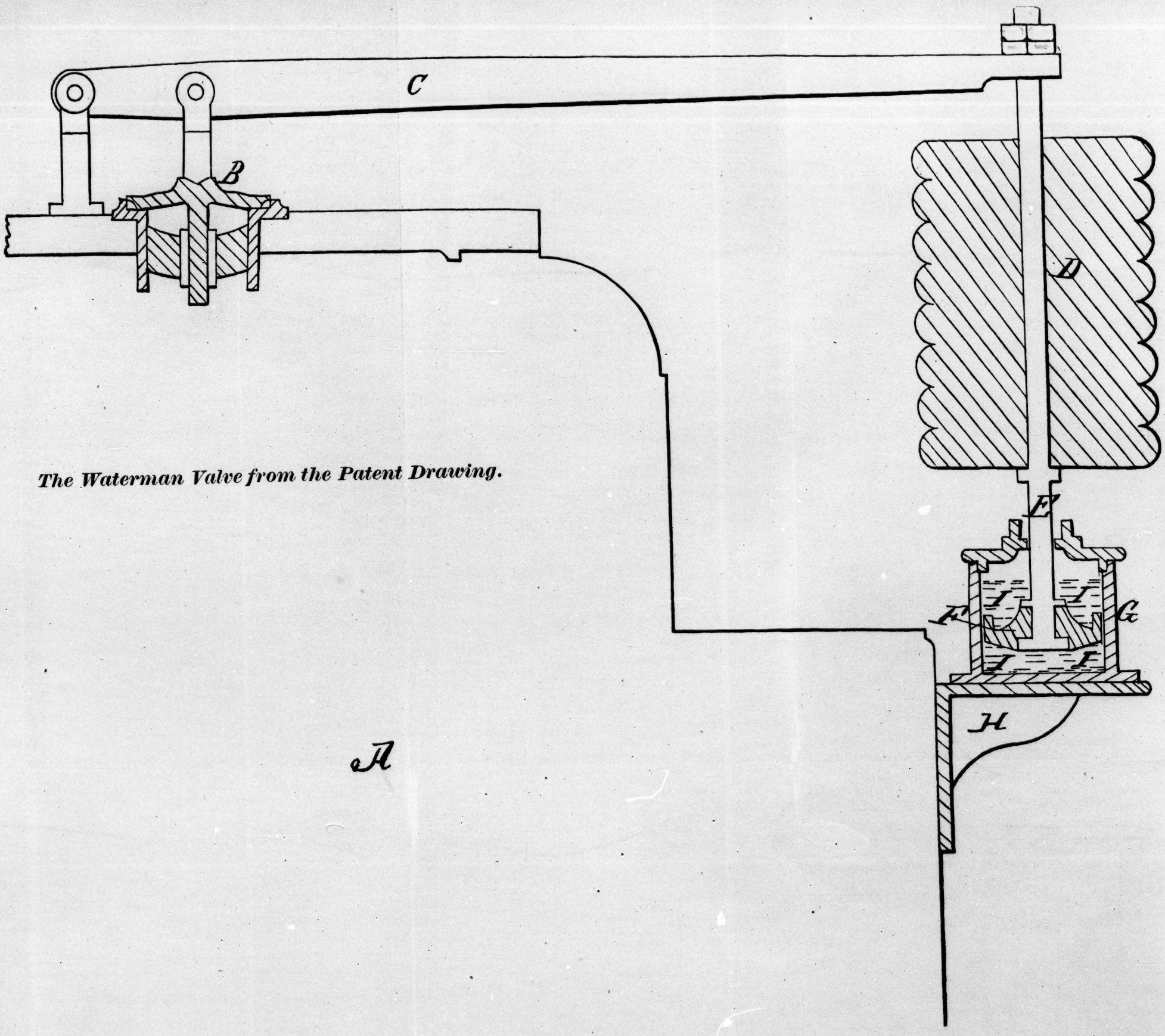
Compiled from Maps and Plats printed for the U.S. General Land Office.

1882

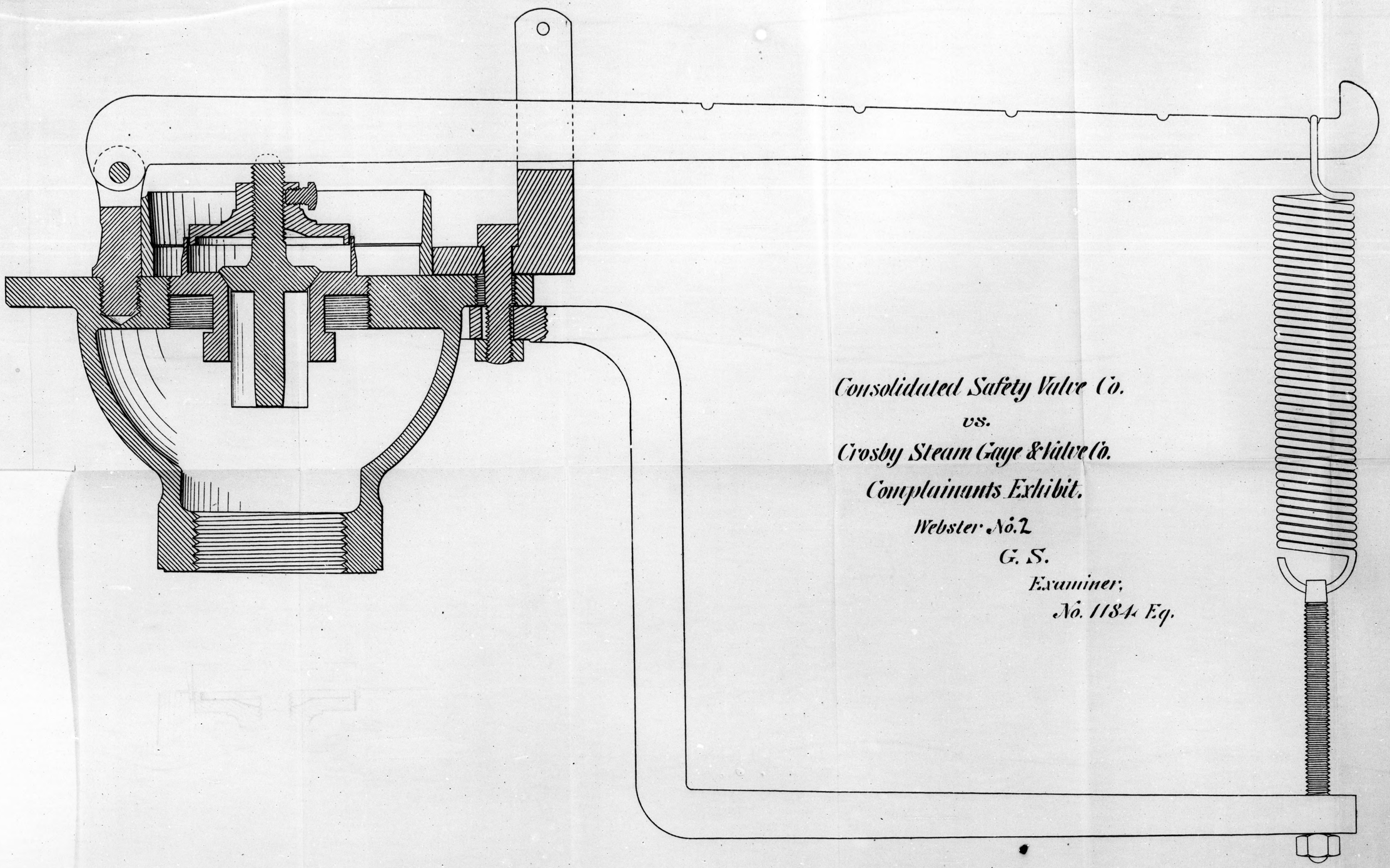
Scale of Miles.

Fig. 1.





The Waterman Valve from the Patent Drawing.



Consolidated Safety Valve Co.

vs.

Crosby Steam Gage & Valve Co.

Complainants Exhibit.

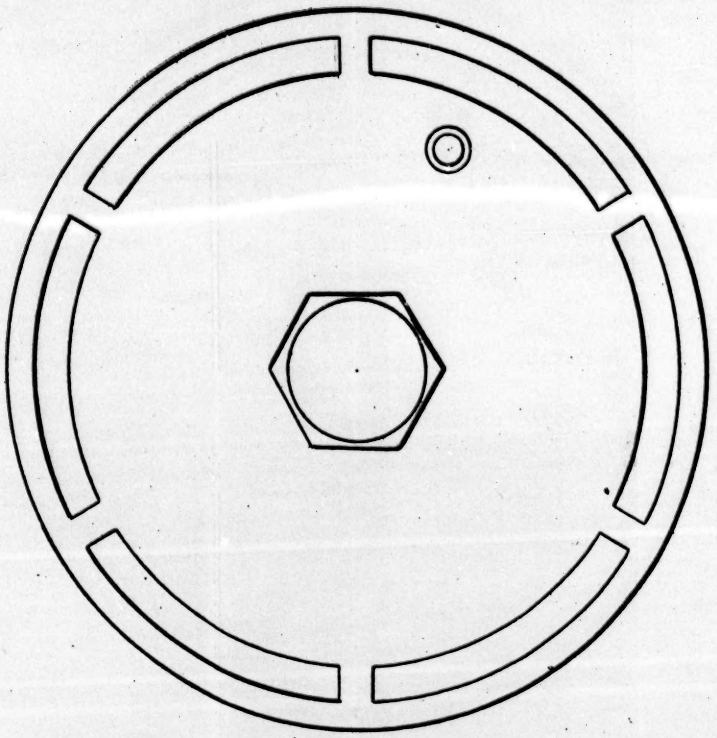
Webster No. 2

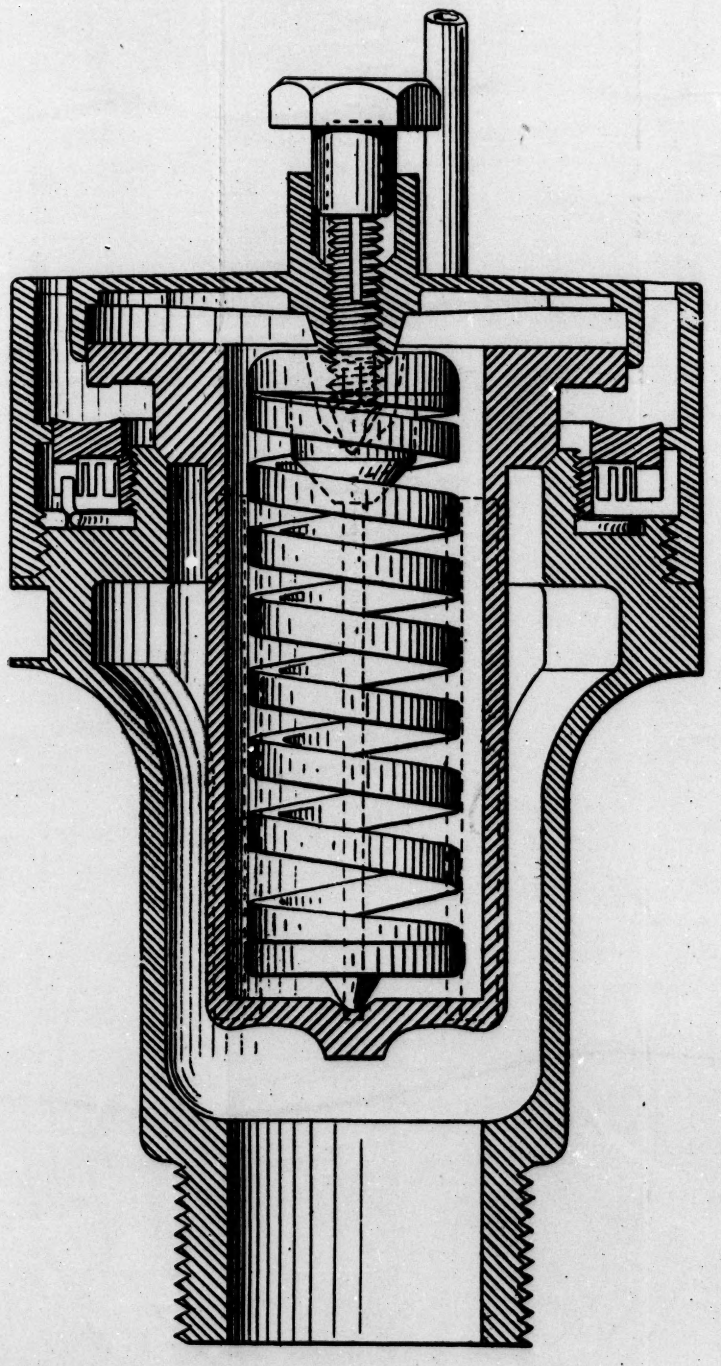
G. S.

Examiner;

No. 1184 Eq.

Complainants Exhibit Drawing Knuckle B.
(Showing Adjustable Screw Ring.)





E. B. KUNKLE.

SAFETY-VALVE.

No. 193,411. Patented July 24, 1877.

Fig. 1.

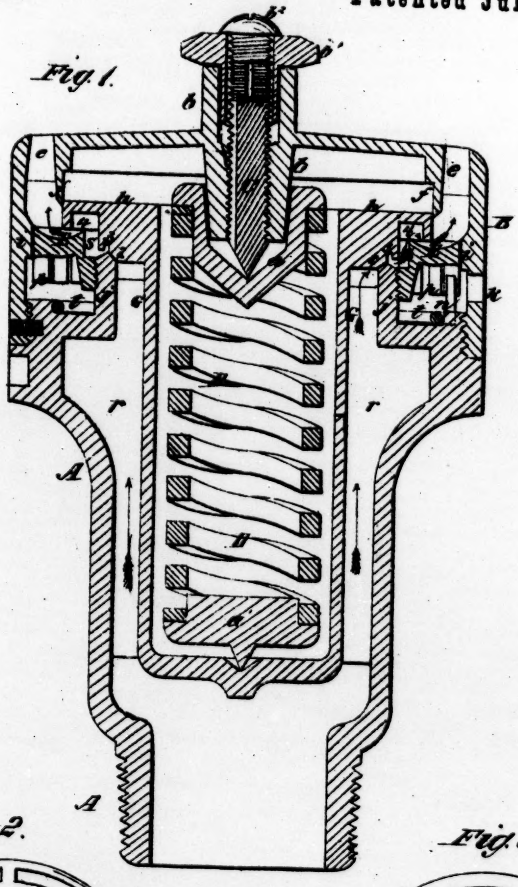


Fig. 2.

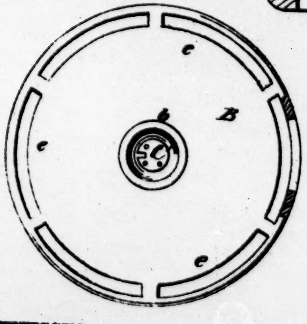
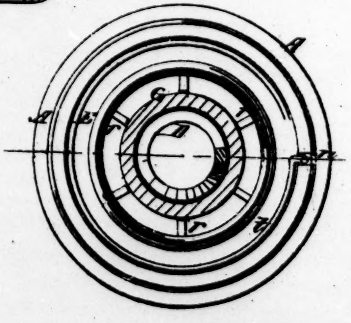


Fig. 4.

Fig. 3.



WITNESSES:

Frances Mc Castle.

J. H. Scarborough.

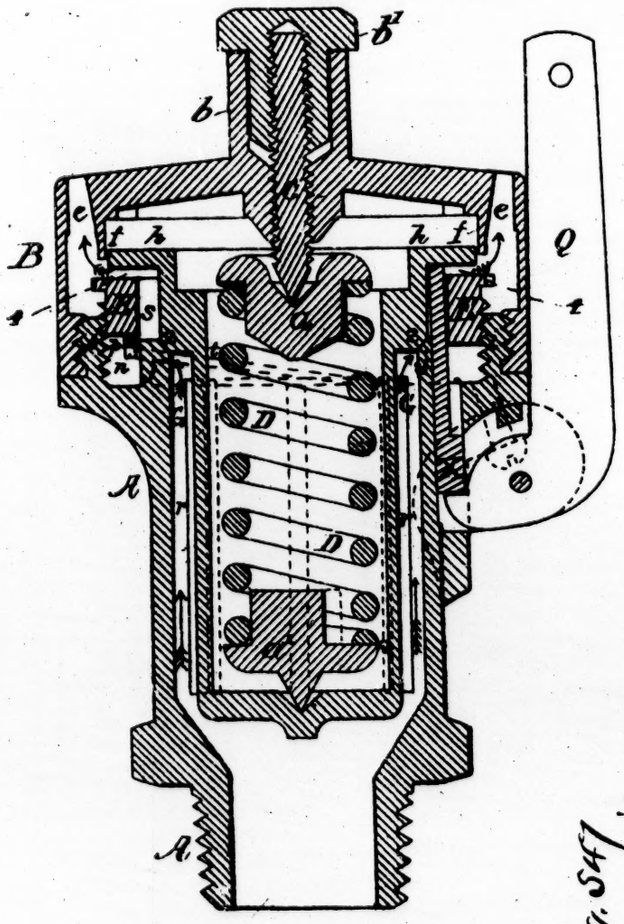
INVENTOR:

E. B. Kunkle

BY Munn & Co

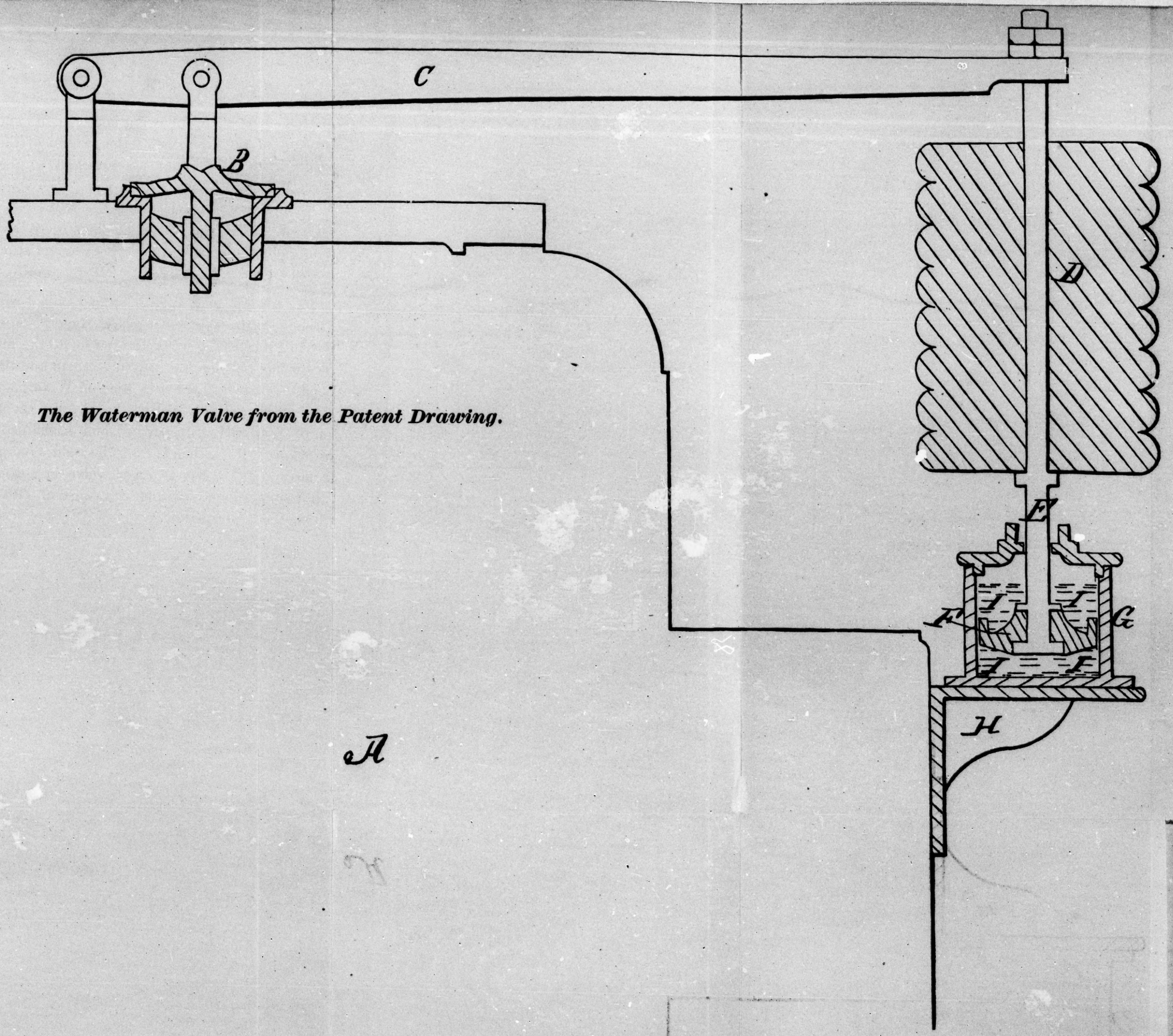
ATTORNEYS.

Complainants Exhibit Kunkle C.²



No. 547.
Consolidated
Safety Valve Co.
v.
Kunkle
Page 178.

E. B. Kunkle Patᵉᵉ & Manufr.
Fort Wayne Ind. Pat. May 4 '75. July 24 '77



The Waterman Valve from the Patent Drawing.

Diagram showing the action of James Webster's Safety-Valve according to Fig. 3 of the drawings which form a part of the specifications of his Letters Patent of Great Britain No. 1955. July 14. 1857, as the same is embodied in:—

Complainant's Exhibit
Webster, Fig. 3, and in

Defendant's Exhibit
Webster. Fig. 3.

References:—

AB, Base line: origin of pressure-reductions from 100. pounds.

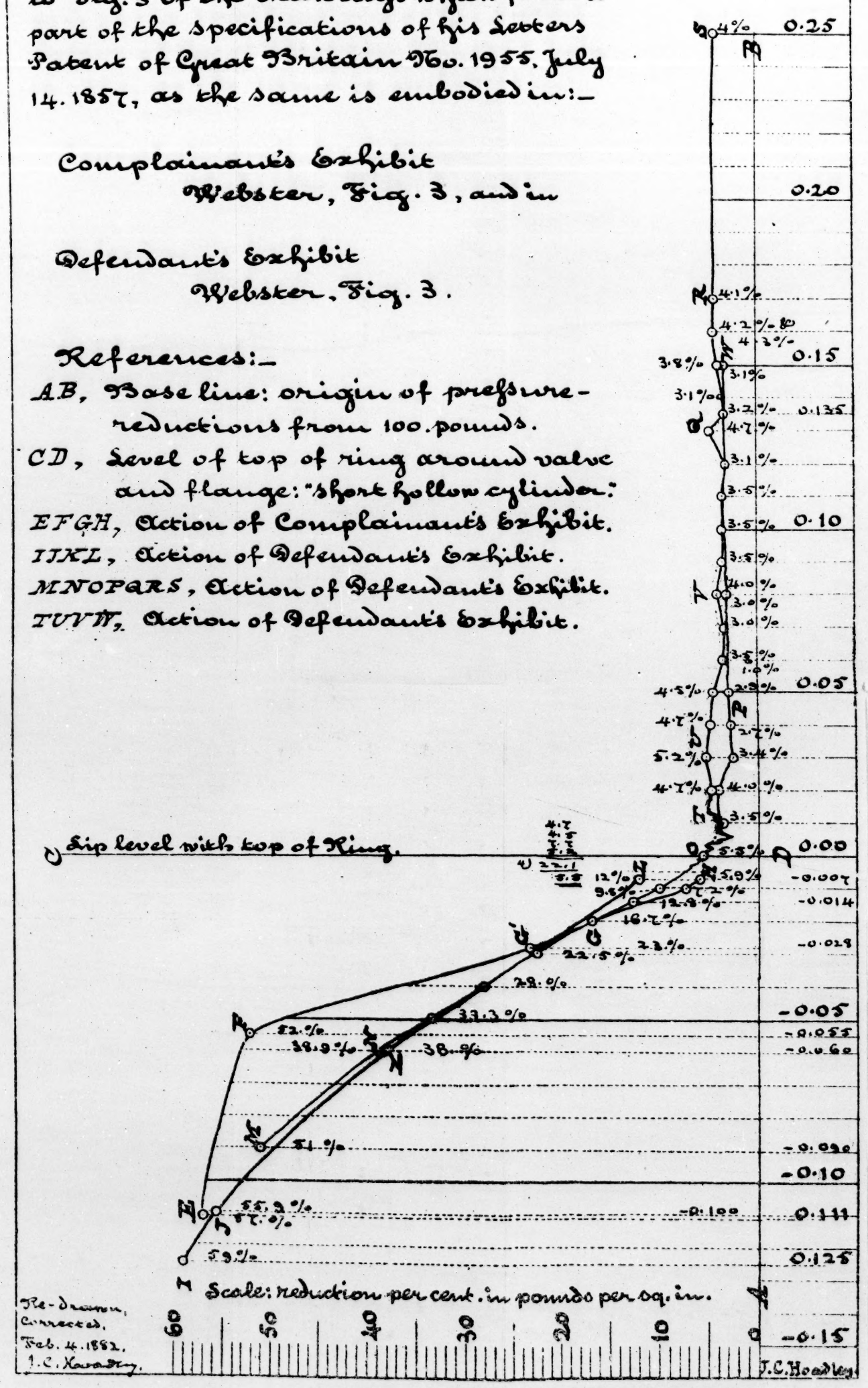
CD, Level of top of ring around valve and flange: "short hollow cylinder."

EFGH, Action of Complainant's Exhibit.

IJKL, Action of Defendant's Exhibit.

MNOPQRS, Action of Defendant's Exhibit.

TUVW, Action of Defendant's Exhibit.



Re-drawn, Corrected. Feb. 4. 1882. J. C. Hoadley.

J. C. Hoadley.

Richardson Patent of 1869 Patent Drawing of

2¼ in Valve - 5 - full size.

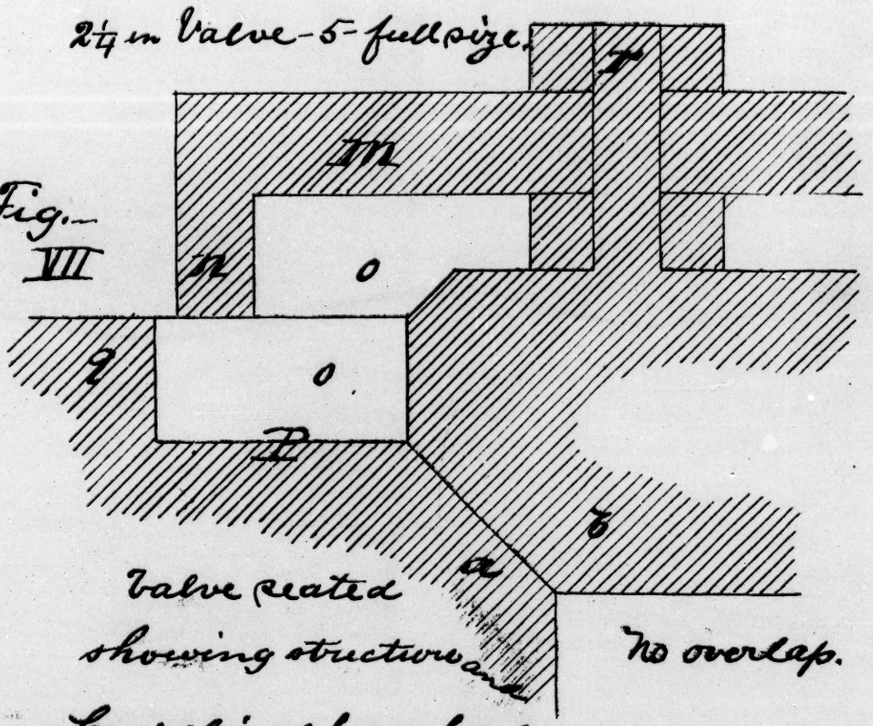


Fig. — VII

Valve seated showing structure and huddling chamber o.

No overlap.

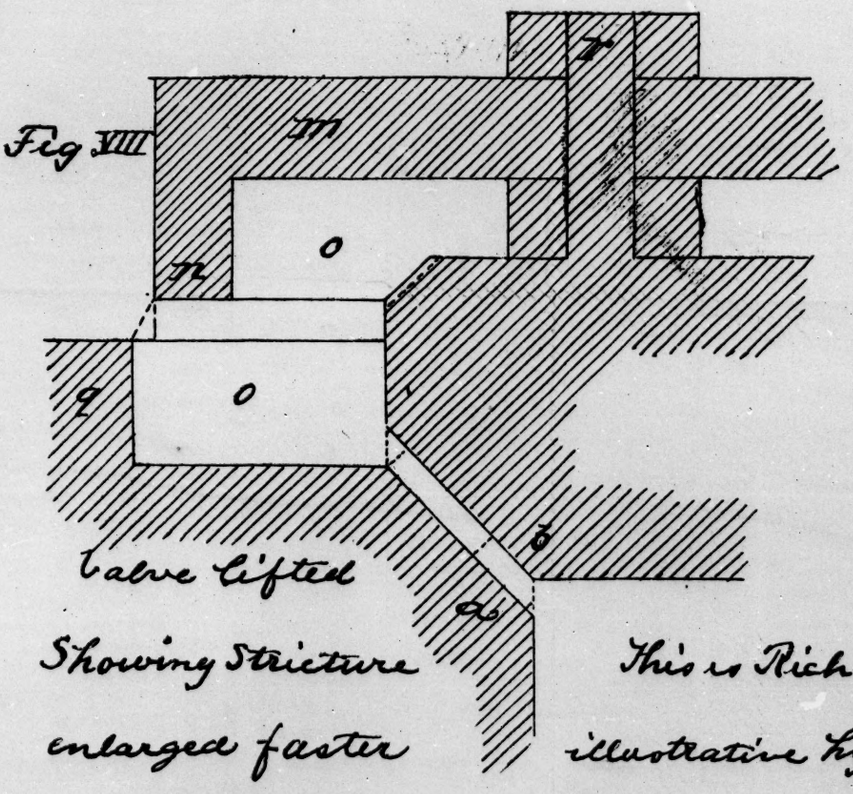


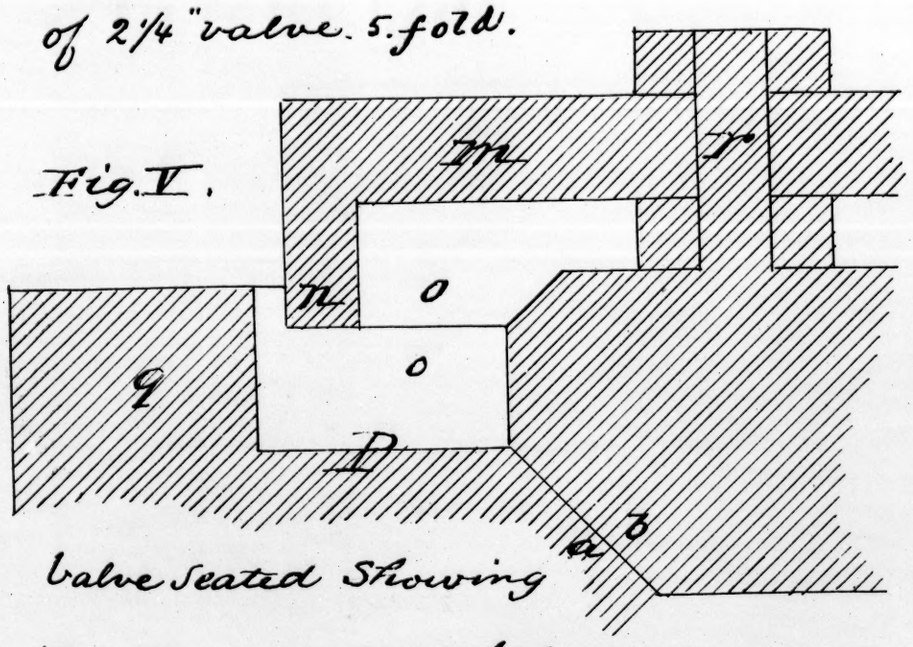
Fig VIII

Valve lifted Showing Stricture enlarged faster than opening of ground-"joint

This is Richardson's illustrative hypothesis, which he truly says won't answer.

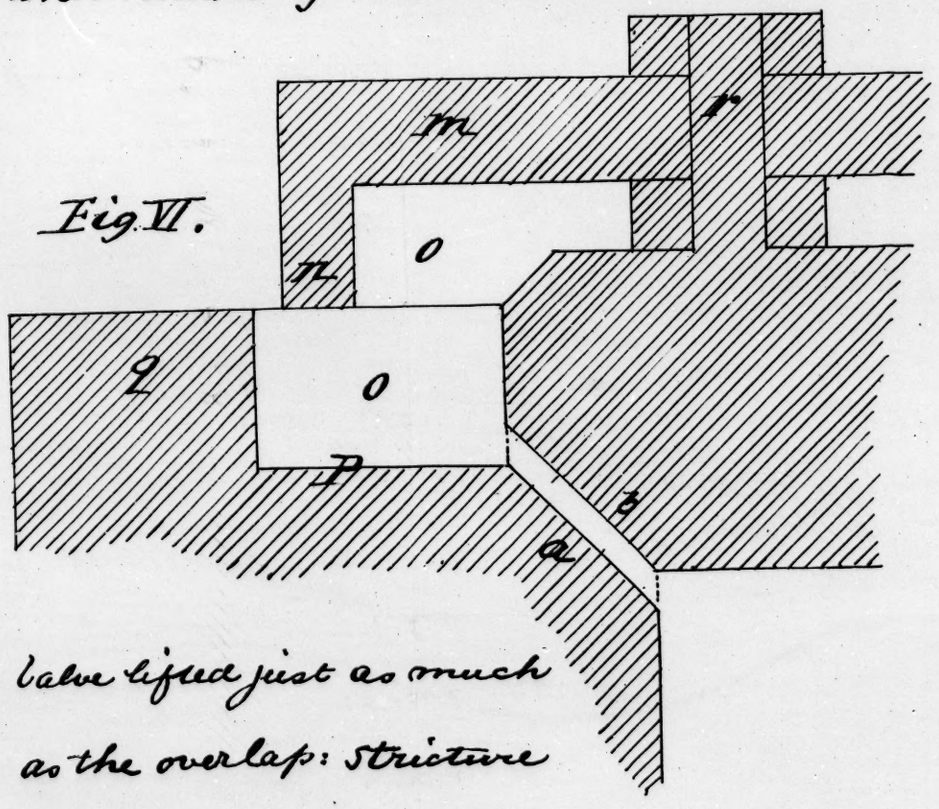
Richardson Patent of 1869. Patent Drawing of 2¼" valve. 5. fold.

Fig. V.

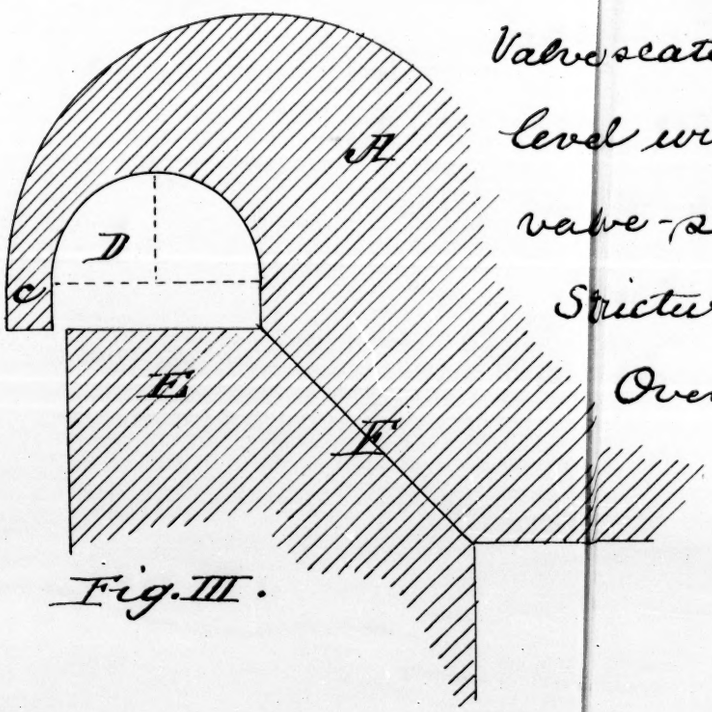


Valve seated Showing structure and overlap and huddling chamber O.

Fig. VI.



Valve lifted just as much as the overlap: Stricture not enlarged. Any further opening will cause the Stricture to enlarge faster than the Ground joint opening.

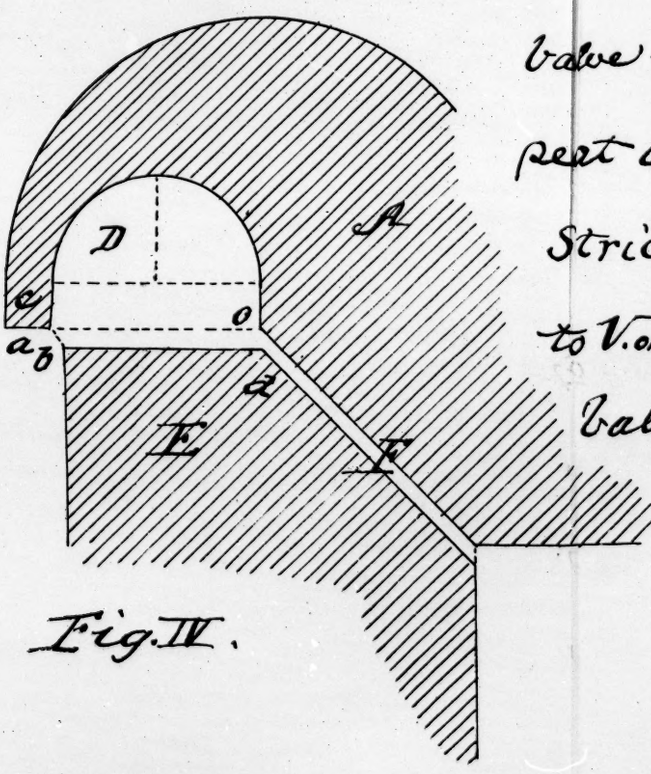


Valve seated: lip level with extends valve-seat:

Stricture $\frac{1}{64}$ inchs:

Overlap 0.

Fig. III.



Valve lifted from its seat 0,025 inch:

Stricture enlarged to $\sqrt{.0156^2 + .0250^2} = .0295."$

Valve opening. =

$.025 \times .7071 = .0177."$

Fig. IV.

"Circumference of Stricture, (middle). = 10.2869" in;

Circumference at ed, outside of valve seat. = 8.7022 in,

$10.2869 \times .0295 = .3034^{\text{"}}$; $8.7022 \times .0176 = .1540$; $\frac{.3034}{.1540} = 1.97.$

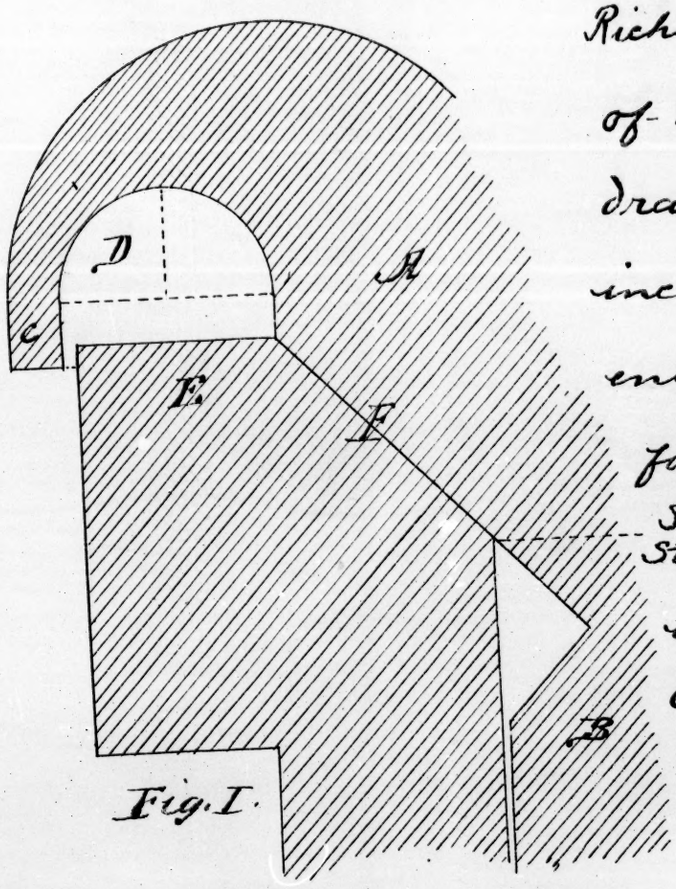


Fig. I.

Richardson patent. of 1866 - Patent drawing. 2¼ inch Steamway enlarged 5-fold Valve Seated: Stricture 64 inch. Overlap 0.025 inch

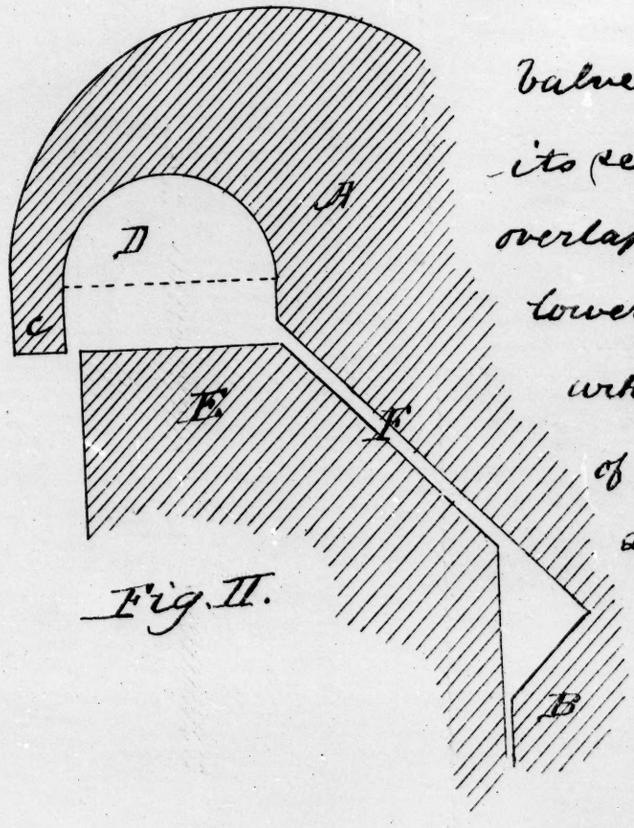


Fig. II.

Valve lifted from its seat 0.025 inch overlap surmounted lower edge of lip level with upper surface of extended valve seat. Stricture not enlarged